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# JOURNAL OF CHEMICAL EDUCATION

*for December, 1938*

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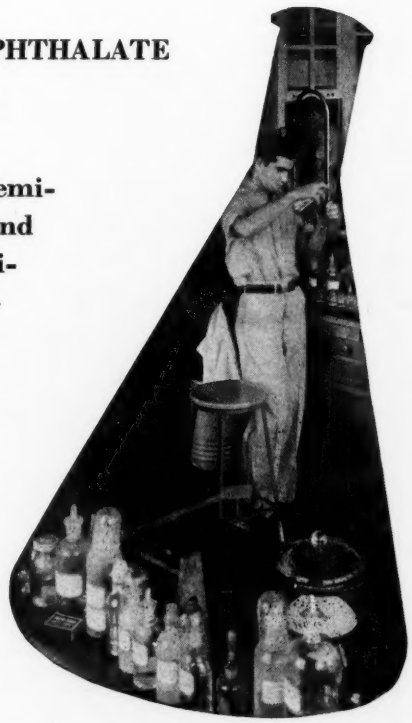

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# HANS A. S. VON EULER-CHELPIN

Hans von Euler, who shared equally with Arthur Harden the 1929 Nobel prize "for researches into the fermentation of sugars and the enzyme action in the process" was born at Augsburg, Bavaria, on February 15, 1873. From 1890–92 he studied painting at Munich, then went to the University of Berlin to devote himself to natural science: physics under Max Planck, chemistry under Emil Fischer and Hans Landolt. After completing his doctorate (1895) he went to Göttingen for physical chemistry under Nernst, then returned to Berlin for a stay in van't Hoff's laboratory, an experience of great and determinative influence on his scientific life.

Von Euler was appointed assistant and lecturer on physical chemistry at Stockholm in 1897, in 1903 he was made assistant professor of organic chemistry. After a period (1904–05) of study at the Pasteur Institute in Paris and under Thiele at Strassburg, he returned to Stockholm as professor of general and organic chemistry. Since 1906 he has been head of the chemical laboratory, since 1928 also director of the biochemical institute and since 1938 of the laboratory for organic research.

He and his collaborators have put out a vast volume of research, which is only partially mirrored in his books: "Grundlagen und Ergebnisse der Pflanzenchemie," 3 vols. (1908); "Chemie der Hefe und der alkoholischen Gärung" (1914); "Chemie der Enzyme," 3rd ed., 4 vols. (1925–34); "Homogene Katalyse" (with Ölander, 1931); "Biokatalysatoren" (1931).

Recognition of his achievements has come from many countries: Honorary member of the Royal Institution and of the chemical societies of Rome, Paris, Warsaw, Bucharest; membership in the Academies of Stockholm, Copenhagen, Helsingfors, Munich, Halle, Göttingen, Vienna, Leningrad; honorary degrees from Kiel, Bern, Zurich, and Athens. He is president of the Swedish National Committee for Chemistry, member of the Nobel Committee for Chemistry, and vice-president of the Union Internationale de Chimie.

(*Contributed by Ralph E. Oesper, University of Cincinnati*)

# EDITOR'S OUTLOOK

IGNORANCE IS BLISS—OF A SORT. Ten years ago, despite the fact that we had just been educated, we still knew so little about education that editorial copy dates never held any terrors for us. We could lay into the subject from almost any angle with enthusiasm and assurance. Of late we had begun to fear that the wisdom of age was overtaking us and drying up, one after another, the founts of editorial inspiration. However, in consultation with our psychiatrist, we have diagnosed this depressing hallucination for the attack of vapors that it is, and are prepared to carry on with renewed vigor. Our eager and expectant readers will doubtless be overjoyed to learn that there still remain educational topics which our ignorance permits us to discuss freely and without embarrassment.

To others similarly afflicted we recommend the treatment that we find helpful—a course of reading in the works of modern educational wise men, preferably on the subject, "What is a university and why?" The things some educators admit they don't know, the things they unwittingly demonstrate they don't know, and the things they know that aren't so furnish the material for a very pretty exercise in laying things end to end and noting how far they reach. We added up as far as the conclusion that there is still ignorance enough to go around, and quit.

Consider by way of instance the concept that used to be called "transfer of learning" when we were exposed to Educational Psychology 201. Broadly stated, the educational aims and ideals of some of our brightest minds seem to imply a rather naïve confidence in this concept. But what, actually, is known of it?

As we recall it now, someone once took the trouble to demonstrate conclusively that there is, within the limits of experimental error, zero correlation between improvement in speed and accuracy in typing and improvement in the stroking and placement of one's tennis backhand. On the whole, our instructor took a rather gloomy view of the possibilities in this respect. Although we do not remember that the subject ever arose in class discussion, he doubtless considered it justifiable and necessary to subject commercial students to special courses in Business English. Even then, most of us grasped intuitively the fact that transfer of learning or skill is possible to the extent that two given situations or operations have similar elements, that the similarity is recognized, and that the skill acquired in one is applied to the other.

But this is at best only an extremely rough qualitative statement, and we cannot be certain that it is altogether accurate qualitatively. Is conscious recognition of a similarity between situations always necessary to a transfer of skill? There is perhaps some reason to suspect that it is not, at least so far as the predominantly physical skills are concerned. To what extent, if any, does the nature of the skill in question affect its transferability? Do the results of experiments based on predominantly physical skills enable us to draw valid conclusions about purely mental skills?

How much do individual differences have to do with skill transference? Where the element of similarity recognition is involved, it would seem that the individual intelligence must become a factor. To what extent does training or experience affect the ability to recognize significant similarities? Are such individual differences perhaps so great as to constitute the fundamental basis for our rough classification of students as educable or ineducable? In short, is the educated man merely the man who can make a little learning go a long way because his transfer facility is high?

So long as these and a thousand questions like them remain unanswered the "fine romance of discussion" need not wither.

# JUSTUS LIEBIG, MAY 14, 1803–APRIL 18, 1873

E. BERL

Carnegie Institute of Technology, Pittsburgh, Pennsylvania

ABOUT one hundred years ago chemistry, through the deeds of our hero, got an upswing which seldom can be observed in the history of any science. In 1837 Justus Liebig was invited by the British Association for the Advancement of Science to read a report on the actual state of knowledge in organic chemistry. The consequence of this invitation was Liebig's book published in 1840 on "Chemistry and Its Application to Agriculture and Physiology." We do not know of any deed of any scientist which has had a greater effect on the welfare of mankind than this book and the ideas developed in it. The conception of the reintroduction into the soil of all those components which form the ash of the harvested plants present in the form of inorganic and organic compounds allows the production of much more foodstuffs than could be produced before Liebig's teachings. Liebig believed that the amount of nitrogen present as ammonium nitrite in the atmosphere and introduced into the soil by rain and mist would be sufficient to cover the needs of the plant for nitrogen compounds. This is the one real error in Liebig's views, which may be explained through the fact that one hundred years ago the important rôle of microörganisms (Hellriegel and others) was unknown.

At this time and later, the ideas of Malthus (1766–1834) were generally recognized. They expressed the view that an increase in the production of foodstuffs takes place according to an arithmetic progression; the increase in the population in a geometric progression. Therefore, too many people will be on the earth and wars, pestilence, and famines must reduce the number of men. We know that through Liebig's work Malthus' laws are no longer valid, and that it would be possible, in this country, to produce foodstuffs necessary for the nourishment of several hundred million people.

In one of his letters to Friedrich Wöhler (1800–1882), Liebig says, "All that we can do, produce, and discover seems to me insignificant compared with what the farmer can do. Our progress in arts and sciences do not improve the conditions of the existence of men, and, if a small fraction of the human society wins in spiritual and material enjoyments of life, the sum of misery in the broad masses remains the same. A hungry man does not go to church, and without a piece of bread a child does not go to school. The progress of the farmer, on the other hand, diminishes the trouble and the uneasiness of men and makes them susceptible for the good and the beauty which arts and sciences acquired, and then gives our progress the foundation and the right blessing."

In 1838 an important paper was published by Liebig and Friedrich Wöhler on "The Nature of Uric Acid and Its Derivatives." This paper is of greatest importance. Here these great men say, "All our knowledge of such substances remain of low value, are only isolated facts without scientific connection as long as we cannot say anything about the manner in which the elements are combined, as long as we are not in a position to develop their rate of decomposition from their composition, and as long as we cannot prove the relationship between the physiological importance and the chemical nature."

PICTURE OF LIEBIG DONE BY TRAUTSCHOLD. NOW IN THE POSSESSION OF THE CHEMICAL SOCIETY IN LONDON



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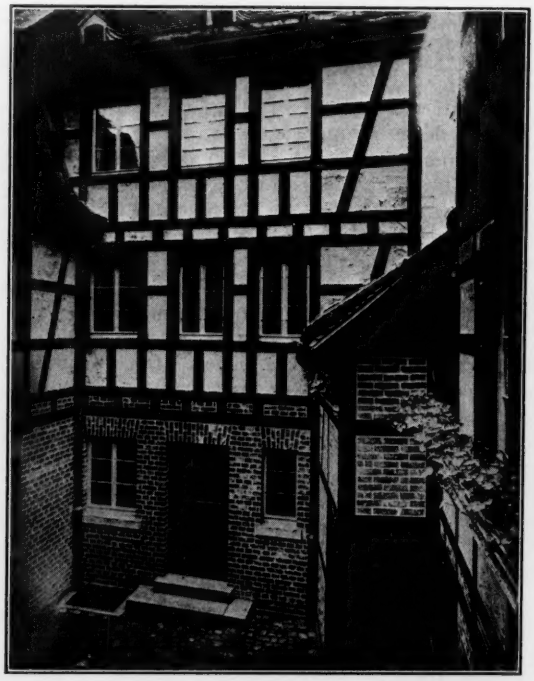
In the same year, based on the work of Graham (1805–1869) published in 1833 on phosphoric acid, Liebig published a most important paper on the "Constitution of Organic Acids." With this publication, which was preceded by a short paper in 1837 with Dumas (1800–1884), Liebig brought clearness in the field of acids, showing that previous ideas of Lavoisier (1743–1794) and Berzelius (1779–1848) that all acids contain oxygen are wrong. In this paper the conception of polybasic organic acids, based on Graham's

JUSTUS LIEBIG. FROM A BAS-RELIEF BY H. JOBST

work, can be found. We owe to Liebig the exact formulation of "equivalent" and "molecule." If one substitutes the term "atomic weight" of an acid used by Liebig by the term "molecular weight," the difference between "equivalent" and "molecule" becomes completely clear. Acids, according to him, are certain compounds where the hydrogen may be substituted by metals. Neutral salts are components of the same class where hydrogen is substituted by the equivalent of a metal. Liebig created in this paper the conception of the basicity of acids. He divided acids into mono-, di-, and tri-basic acids. Kekulé (1829–1896) twenty years later, developing his structural chemistry, wrote, "A large part of the present views is nothing else than a further expansion and a consequent accomplishment of the view used in the theory of the polybasic acids."

In this same year, 1838, Liebig published a paper on Laurent's (1807–1853) theory of organic compounds. In 1825, one year before Balard (1802–1876) discovered bromine (malicious tongues said that the bro-



COURTYARD OF THE LIEBIG HOUSE IN DARMSTADT

mine had discovered Balard) Liebig had isolated bromine. During his whole life he never forgot that the great ambition of a scientist—to have discovered a new element—was not attained by him because he adhered to a wrong theory. Thirteen years later he expressed this in his language of impassioned eloquence, "I know a chemist who, while at Kreuznach, many years ago, undertook an investigation of the mother-liquid from the salt works. He found iodine in it; he observed, moreover, that the iodide of starch turned to a fiery yellow by standing overnight. The phenomenon struck him; he procured a large quantity of the mother-liquid, saturated it with chlorine, and obtained by distillation a considerable amount of a liquid coloring starch yellow, and possessing the external properties of chloride of iodine, but differing in many of its reactions from the latter compound. He explained, however, every discrepancy most satisfactorily to himself; he made a theory for himself about it.

"Several months later, he received the splendid paper of Mr. Balard, and, on the very same day, he was in a condition to publish a series of experiments on the

behavior of bromine with iron, platinum, and carbon, for Balard's bromine stood in his laboratory, labeled 'Liquid Chloride of Iodine.' Since that time, he has made no more theories unless they are supported and confirmed by unequivocal experiments; and I can positively assert that he has not fared badly by so doing."

In the same paper (on Laurent's theory of organic compounds, 1838) Liebig writes, "In the period of development of every science from the publications of the period result certain general relations which, through new discoveries each moment, are changed and improved; there results a tendency to arrange the acquired discoveries and to find the common tie which binds them together. Our theories are the

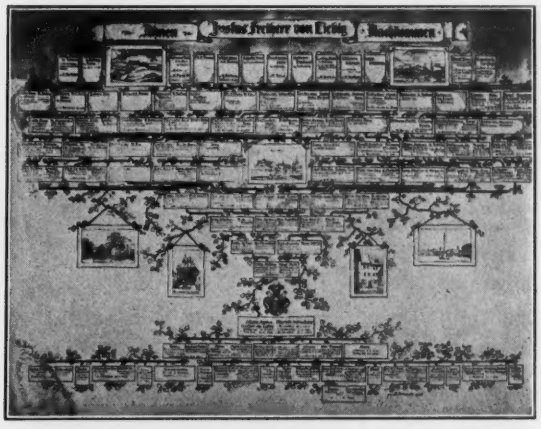
PICTURE OF SCHLEIERMACHER FOUND IN THE LIEBIG HOUSE

expression of the views of the time; true in this respect only are the facts, the explanation of their relation only more or less approaches the truth."

In 1839 Liebig developed his far-reaching ideas concerning fermentation. His publication on the "Phenomena of Fermentation, Putrefaction, Decay and Their Causes" taught that a substance which itself is in a stage of transformation can produce a similar transformation in another substance in contact with it, or can make it capable of suffering the same changes which occur with itself. With this important publication and in letters (1837–1839) to Wöhler, Liebig came in opposition to Berzelius' conception of the "catalytic power" which this great Swedish scientist, first Liebig's friend and then his enemy, coined in 1835. Liebig's views on fermentation, the transfer by a kind of molecular impacts, were the starting point of discussions with Pasteur (1822–1895) in 1860 and 1870. We see the renaissance of these views in modern theories concerning the transfer of molecular oscillations.

One hundred years ago Liebig was at the zenith of his experimental work which was the basis for those far-reaching summations of ideas which he afterward published in the form of books, and which, as the work of no other scientist, have influenced organic chemistry, agricultural chemistry, and physiological chemistry.

Ten years ago the writer published letters* of Liebig which, as a young man, he wrote to his parents, to his protector, Schleiermacher†, and to a friend, August Walloth. These letters were written in Heppenheim (near Darmstadt) when he was a boy of fourteen or fifteen years, during his stay in Bonn and in Erlangen with K. W. G. Kastner (1783–1857), and in Paris.



FAMILY TREE OF JUSTUS LIEBIG. ORIGINAL IN THE LIEBIG HOUSE

The most important letters are those which Liebig wrote from Paris. Through Schleiermacher's intervention, the Grand Duke Ludewig I of Hesse (1753–1830) gave money for his studies there (1822–1824). Based on these letters, several of which are badly damaged by the "censorship of mice," and based on letters which Liebig wrote during the first years (1824–1827) of his professorship in Giessen to Schleiermacher, it seemed possible that in the archives of the Hessian government in Darmstadt further letters of Liebig

* Liebig's letters to his parents are in the possession of Mr. Karl Liebig, Valparaiso, a grandson of Liebig's youngest brother, Karl. The letters to Schleiermacher are in the personal archives of the former Grand Duke of Hesse. The letters to Walloth belong to the city of Darmstadt.

† Schleiermacher, belonging to a family whose members contributed to progress in spiritual life, was the cabinet secretary, and the right hand of the Grand Duke of Hesse. Schleiermacher established an antediluvian cabinet at Darmstadt which at this time and later was of outstanding importance.

might be found concerning his proposition to build a hydrochloric acid and bitter salt ($MgSO_4$) plant in Salzhausen (Hesse) (1824–1829). By a happy accident these documents were unearthed. They were also published in 1930 by the writer. They give a very interesting picture of Liebig's character and of the industry of heavy chemicals a hundred years ago in South Germany.

We may understand some of Liebig's great qualities when we go back to his ancestors. On his father's side they were farmers near Darmstadt.* We do not know of anyone among them who had ever shown intelligence above the average. Liebig's father (1775–1850) was a kind of a Faust. He was the owner of a small drugstore, producing and selling inorganic paints, lacquers, and varnishes. He prepared some of the materials to be sold, and he made experiments in a small laboratory. It may be interesting to note from Liebig's letters that his father introduced illumination with gas very early, and made experiments with manures. We may well believe that Liebig's outstanding work in agricultural chemistry probably started from discussions at home. Liebig's genius certainly came from his mother's (1782–1855) side (as this is often observed with other great men). Liebig's mother, Maria Carolina, was an illegitimate child. According to one version, her father was a journeyman tailor from Ulm who afterward perished in the storms of the French Revolution. Another version of greater probability seems to prove that Liebig's grandfather was a Jewish merchant. When, in 1928, the writer visited a member of Liebig's family, he heard the words, "You know certainly that we Liebigs have Jewish blood in our veins."†

*From "Mothers of Famous Men"*
LIEBIG'S MOTHER

Justus was the second-born of ten sons and daughters. With the exception of him, none of them was distinguished with any outstanding intellect. Here Nature produced one of those inexplicable phenomena, in creating one individual with such outstanding qualities that his head touched the stars.

Liebig's mother was the cause of successful speculations during the Napoleonic Wars which brought well-being to the Liebig family. Before the Continental Blockade started, she bought great quantities of sugar which were sold during the blockade with profit. She convinced her husband that the necessary money should be given to Justus so that he could study under K. W. G. Kastner in Bonn and Erlangen. His stay in Paris cost more money than he got from the Grand Duke of Hesse. His parents paid the balance. His mother certainly very often calmed down the impetuous character of her husband which was inherited by Justus who describes himself as a "vehement and impetuous man." Pictures show that Liebig had his mother's wonderful eyes, hooked nose, and high forehead.**

It is known that Liebig left the high school of his native town at the age of about fourteen because he was not interested in the philological education given there. He came to a pharmacist in Heppenheim, near Darmstadt, where he was not treated well. He returned to Darmstadt. He spent two years there in the store of his father, and became acquainted with materials of all kinds and their properties, carried out different experiments in the laboratory where his father worked, and read all the books on chemistry which he could find in the library of the Grand Duke of Hesse. Here he learned to "think in phenomenons."

It is very interesting to see from the letters written by young Liebig in Bonn and in Erlangen how excellently he was informed concerning the properties of

* After the War of Thirty Years one of Liebig's ancestors married a Jewish girl named Bliha.

† Liebig today could not occupy a chair in one of the German universities. The same would be true for his successors, Adolf von Baeyer (1835–1917) and Richard Willstätter (1872–). The world would be much poorer in many respects if those great men would have been banished from their important work by race hatred. In 1871, after the war between France and Germany, Liebig himself found eloquent words against such prejudice, "It will be on the neutral ground of science that the best minds of the two nations must meet in endeavoring to reach the high goal common to both. The feeling of fraternity will gradually contribute to mitigate the bitterness with which the deeply wounded national pride of the French is filled."

** Liebig's sister, Elise, writes (May, 1870) to one of her sons, "We children of my great mother do not fear death."

many different materials. In his seventeenth and eighteenth years he gave his father much information about the production of inorganic dyestuffs of different kinds.

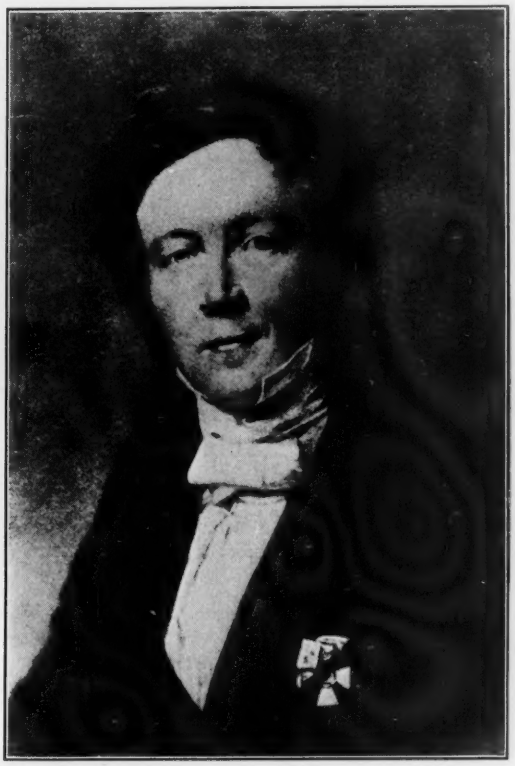
At this time Kastner was one of the best known professors of chemistry in Germany. With the exception of Doebereiner (1780–1849), who carried out most important work in Jena, Mitscherlich (1794–1863) in

*From "Von Davy und Döbereiner bis Deacon" by Mittasch and Theiss*
WOLFGANG DOEBEREINER

Berlin, and Strohmeyer (1786–1835) in Göttingen, no men who were outstanding in chemistry taught in Germany. Kastner belonged to those professors of this period who in their teaching used confused, natural philosophical ideas. Liebig afterward described Kastner's teaching in chemistry as rather poor. This teacher could not give him much, but it seems that his influence was, nevertheless, important. He recommended Liebig to the Grand Duke of Hesse and to the faculty of the Giessen University. Through him Liebig got his doctor's degree at the age of twenty. A paper, dating from his Erlangen period but published in 1822 when he was in Paris, is remarkable because Liebig describes experiments on silver fulminates which were carried out by him during the previous two years (therefore, in his seventeenth and eighteenth year).

About one hundred twenty years ago Darmstadt, the capital of the Hessian-Darmstadt state, was a rather small place of about fifteen thousand inhabitants. Schleiermacher, the Grand Duke's chancellor and a friend of the great Cuvier (1769–1832), certainly knew Liebig's family very well. On the recommendation of Kastner and Schleiermacher, the Grand Duke Ludewig I of Hesse spent most of the rather large sums necessary for Liebig's studies in Paris (from November, 1822, to April, 1824) in spite of the fact that Justus was somewhat entangled in student unrest in Erlangen. Never was money better used than in this case. Here in Paris Liebig saw the light of the world.

The young Liebig felt at this time that the great Berzelius (1779–1848) in Stockholm and his pupil, Mitscherlich (1794–1863) had perfected to a certain degree the so-called mineral chemistry. Further great development was to be expected in the chemistry of plant and other organic matters. The French school



*From "Von Davy und Döbereiner bis Deacon" by Mittasch and Theiss*
EILHARDT MITSCHERLICH

with Chevreul (1786–1889) and Gay-Lussac (1778–1850) had just carried out outstanding research in this field. Great teachers and research men taught at this time in Paris. This apparently was the reason for Liebig's studying in Paris. In his younger years Liebig had no interest in politics, arts, and music; his only interest was chemistry, nothing but chemistry. (The Grand Duke of Hesse was one of the great admirers of Napoleon who died only a year and a half before Liebig came to Paris.)

Some of Liebig's early letters may be reproduced which show his early maturity, his steadiness in pursuing his aims, and his incredible diligence. In practically all his earlier letters wishes are expressed for money from his parents and from the Grand Duke of Hesse through Schleiermacher. In his later life Liebig was immune toward money. Letters from which his impetuous character can be seen, and which brought him in temporary opposition to his father and to the Hessian envoy in Paris, are not reproduced here. This selection is ended with a letter to a friend of his youth, August Walloth, from which Liebig's kindness and his method of working can be seen.

In these letters the wonderful relationship between Liebig and Wöhler is not mentioned. It may be

MERCK ROOM IN THE LIEBIG HOUSE IN DARMSTADT

fitting to cite here Liebig's own words of characterization of the fundamental, different talents of both great heroes.

"While in me the disposition prevails to search for the resemblances in the behavior of substances or their compounds, Wöhler possessed an incomparable power of observation for differences; a sharpness of observation was combined in him with an artistic skill and a geniality in finding new ways and means of examination or analysis as only few men possess them."

Like Pasteur, Liebig was a passionate fighter all his life. Both tried to find the truth; both helped mankind better than anyone before or afterward. Liebig's best friend, Wöhler, could not change his opinions, especially not in his later life. He and Berzelius later on could not come together, and they separated in 1845 as the worst enemies.

### TO HIS PARENTS, BONN, NOVEMBER 1, 1820

This semester I have taken experimental chemistry, experimental physics, and pharmaceutical chemistry. I take these courses and I hear also meteorology, encyclopedia of the natural sciences. I am rather busy this winter. In summer I may take mineralogy, and so forth. Kastner promised me that I may be present as an assistant in his private experiments. This would be a wonderful opportunity if he keeps his promise. I see him from time to time. I told him also about my treatment of cobalt ores and the very peculiar phenomena which happened thereby. He desires now to analyze this ore in my presence, and he asks me to bring him more of it. Therefore, send at once at least four ounces and add at least two lots of the mineral green of Gotha and two lots of our self-produced myrin and the dissolution of the cobalt ore and the yellow residue from the evaporated nitric acid solution and a small sample of Viennese green which I have made and the calcined cobalt ore.

I take great pleasure in my studies. The more one penetrates into it, the more it pleases one. Now I perceive how little I know and how much I must learn so that I can say, "*I know something.*"

### TO HIS PARENTS, BONN, FEBRUARY 1, 1821

Yesterday we made lead chromate, glowing iron chromate with saltpeter, extracted it, and, with the dissolved potassium chromate, we precipitated a solution of lead acetate, but so that acid was in excess. The precipitate settled magnificently. Also we produced the morphine, this special alkaloid from the opium which may be the essential part of the Aqua Tofana. We ground one ounce of opium with concentrated acetic acid until the mixture was uniform, filtered the acetate of morphine, added ammonium, wherby it did precipitate. The filtered liquid contained the meconic acid, which was precipitated with acetate of barium, as barium salt of meconic acid and was precipitated afterward with . . . . . K. describes in his magazine a process to produce oxydized calcium chloride which he recommends as a remedy to promote the growth. At Schönebeck a plant for this fertilizer has been established. I will furnish you the description of its preparation . . . . .

### TO HIS PARENTS, BONN, FEBRUARY 20, 1821

I have prepared the new metal, cadmium, from the Silesian zinc, also iodine from the sodium salt of hydro iodine acid, cinnabar and the blue molybid acid, tin oxide, which is known as Richters blue carmin. To produce blue carmin from the indigo, one needs an addition of alum earth. One now gets many earthen vessels from London which are covered with platinum, which are not attacked by any acid, even vitrioloil. They are used as coffee things, candlesticks, and so forth. The platinum has the same value as silver. If experiments would give good results, one could make enormous sums of money because the vessels are in great demand.

### TO HIS PARENTS, ERLANGEN, MAY 20, 1821

I take botany this summer with Professor Schubert, and technology, crystallography, and physics. I will do a lot of work this summer with botany because I need this very badly. Kastner gives us chemistry only in the winter semester. I need also Kurt Sprengel's "Science of Herbs."

### TO HIS PARENTS, ERLANGEN, NOVEMBER 18, 1821

During this summer I have studied physics, botany, and technology with all diligence. Whether I will accomplish anything in those professions, time will show. The future is no longer dark before my eyes. I have made up my mind to devote myself completely to teaching. Kastner himself has encouraged me in this. I awake, so to speak, to a new life because I see before me the goal which I want to reach. This winter, according to a proposal of Kastner, I shall furnish an analysis of a fossil. This is intended to be printed in a journal so that I may be known a little in the learned world. Kastner will send a copy of this publication directly to the Grand Duke whom he knows personally. He will recommend me and, at the same time, ask for a scholarship for me. Then if the Government is on my side, and I have no doubt that this will be the case because chemists are rare in our country, I will have made my fortune.

Because chemistry and physics are no faculty sciences, I shall give a course in Darmstadt in experimental chemistry, and, if I get approval, I shall easily get a call to a university, or

in association with other men, according to Kastner's wishes. I could establish an institute like that of Trommsdorf which certainly will be supported by the State. Therefore, during this winter, I study chemistry and analysis with great diligence and zeal. I am studying languages and mathematics, and I hope that I shall meet your expectations some day.

TO SCHLEIERMACHER, PARIS, NOVEMBER 26, 1822

The classes started November 8. I attend the course in physics given by Gay-Lussac, chemistry by Thénard (1777–1857), mathematics, zoölogy, and mineralogy. At the Royal Academy one course lasts a whole year. The lectures are divided, therefore, into two parts. In the second semester of the course, the teachers of the first term are replaced by other professors; therefore, during the next summer term Gay-Lussac will be replaced by Biot (1774–1862), and Thénard by Dulong (1785–1835) so that the latter continues and finishes the lectures which the first have begun.

TO SCHLEIERMACHER, PARIS, JANUARY 17, 1823

Concerning natural sciences, there is no other country (meaning France) where they flourish so much and where they are so much a part of the practical life. This can be explained only by the outstanding mathematical disposition of the French scientists, rejecting everything which is useless and hypothetical. Gay-Lussac treats chemistry as a great master. The same is true for Thénard. The experiments are carried out by using materials lavishly. In this respect the governemnt does not spare any expense, and it seems as if the French want to impress the masses by brilliant experiments. Foreigners are getting along very well because outside of Paris it would be difficult to find such a combination. Gay-Lussac possesses also the special art of accomplishing very much with very little. Thénard seems to be less gifted in this respect.

Clement's (1779–1841) application of chemistry to arts has a purely practical tendency. One finds used in his lectures everything in relation to life and, furthermore, useful things newly discovered or invented for factories. Because Clement is known as an excellent chemist one always finds new and interesting results in his lectures. It would be a very great pleasure to me if you would allow me to tell you those things in the future.

Through the kindness of Professor Knuth, collaborator of Mr. von Humboldt, I had the opportunity to attend the meeting of the Royal Academy, and had the pleasure to make the acquaintance of Vauquelin (1763–1829), Gay-Lussac, and other illustrious men. The greatest sensation in this meeting was the discovery of a compound of iodine with a hydrocarbon which was obtained by bringing a compound of metallic potassium with antimony in contact with a solution of iodine in alcohol. It forms a white, solid mass.

TO HIS PARENTS, PARIS, FEBRUARY 17, 1823

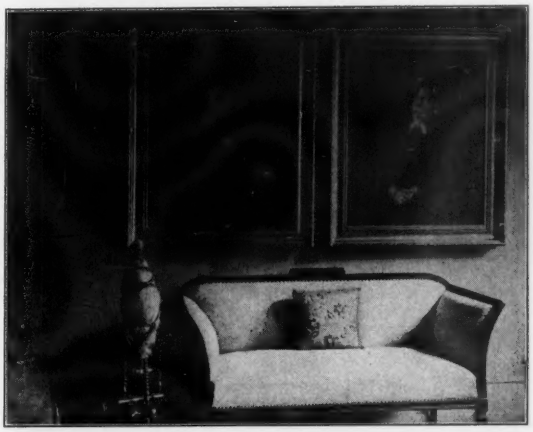
You asked me for the description of a distillation apparatus. In view of your rather small requirements, it would not be advisable for you to have such an apparatus built for 5000–6000 florins. How easily such a sale stops and then the apparatus stays in the lumber room! The distilleries here are really at the top of perfection. Nowhere can one see more perfect machines for distillation. Where thirty to one hundred men were used, only three to ten men will do their work today just walking around. The apparatus are constructed in such a way that they are filled automatically, and in the outside condensers one always finds strong alcohol. In the course in chemistry which I take with Clement-Desormes, chemistry applied to arts, this process must be discussed very soon and I will send you the calculations.

TO AUGUST WALLOTH, PARIS, FEBRUARY 23, 1823

Vain on my very little knowledge, I came to Paris, expecting my life here would be only a promenade, and all at once I find myself among people of whom I am the most insignificant. It struck me like a bolt from the blue sky, but what a beneficial thunderbolt! The old tree of prejudice with its deep roots is smashed, and in place of the old there is growing up a slowly-developing, new tree with green foliage, and I hope, because the destruction is at the same time the blossom, a fruit-bearing tree will result. You see that a metamorphosis has taken place in me in the meanwhile. The lectures of Gay-Lussac, Thénard, and others are the cause of this. Science is no longer an old horse which one has only to saddle so that one can ride on it. It is like Pegasus—the more I try to reach it, the more it flees from me.

I thought I had worked hard in Darmstadt, but in Paris the daily song is from seven in the morning until midnight and later, and I enjoy it.

I neglect my beloved Latin, but instead I am studying Italian and afterwards English. I must say that I am making progress in Italian. I am getting along rather nicely with the French



PORTRAITS OF LIEBIG AND FRAU LIEBIG BY THIERSCH

language. It progresses rather slowly. I believe I could speak fluently at home, but here in Paris I am still a great bungler. I am glad I have no more difficulties in my courses and understand all in my conversation but my own talking. . . . .

TO HIS PARENTS, PARIS, MARCH 30, 1823

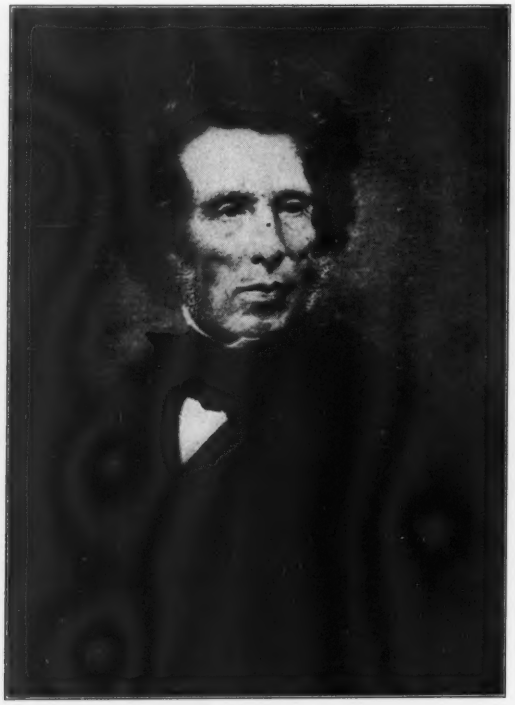
The second series of lectures have now started and instead of Gay-Lussac and Thénard, Dulong and Biot are lecturing. The diligence of the French scientists must be praised very much. Up to now nobody thinks of taking a vacation. The Easter holidays passed without my enjoying the festival. As usual the lectures ended on Saturday and were continued on Monday, the second holiday. Only in August the long vacation starts. It lasts two or three months. I hope I can do a lot of work during this time because I will have leisure enough for making up my studies. The time during the semester is not sufficient.

KASTNER TO GRAND DUKE LUDEWIG,
ERLANGEN, JUNE 29, 1823

Your Royal Highness had the grace to grant my most submissive request to support the young Liebig. Expressing my deepest gratitude I take the liberty to enclose the diploma which, on my proposal, the faculty unanimously conferred on Dr. Liebig, hoping and wishing that Your Royal Highness will always bear my brilliant pupil in gracious remembrance. His work will be a blessing for your country, and I am certain that in the years to come Liebig will bring respected advantages to his fatherland and to science.

LIEBIG TO HIS PARENTS, PARIS, AUGUST 6, 1823

I mentioned in my last letter (of July 17, 1823) that I made an interesting discovery, and that I delivered a memorandum to the Royal Academy. I want to give you more details. I have found an acid which is formed by the action of alcohol on nitric acid. The combination of this acid with metal oxides forms the silver fulminate, the mercury fulminate, and others. Then I have discovered a copper fulminate, an iron fulminate, a zinc fulminate, and many others which have given many headaches to the French scientists. You will read these things later on. My memorandum was thus ready. It was looked over once more by Thénard and then we went together to the Academy. To my



FRIEDRICH WÖHLER
PORTRAIT IN POSSESSION OF THE GERMAN CHEMICAL SOCIETY

great surprise, my paper was read first. Thénard, being president of the Academy, could not read it, but Gay-Lussac had the kindness to report on it. I brought the new salts and preparations along with me and placed them before the assembly. During the reading of my rather long memorandum, the audience showed their appreciation, and at the end of the lecture the members gave me the most convincing mark of approval. Even Mr. von Humboldt, the famous traveler, came to me and talked with me nearly one hour. Finally Gay-Lussac and Dulong were named reporters. They will make the report to the Academy on Monday. I am certain that it will be in my favor. In the following months it will probably appear in the Annales de Chemie, and I shall send several copies to my most gracious prince, and to Honorable Mr. Schleiermacher. I am convinced that this will give them great pleasure.

Counselor Kastner got a copy immediately and you will read it in German in his journal next month. I sent it also to Oerstedt (1777–1851) in Copenhagen and to Thomson (1773–1852) in London.

TO HIS PARENTS, PARIS, OCTOBER 6, 1823

My situation has not changed at all. It has improved because I get acquainted with many highly respected chemists. Since my last paper I am no longer considered a stranger. I am, so to speak, admitted to their caste. One supports me in every respect, I mean in scientific matters, and this is all that I can wish and that is necessary to me. I am now in correspondence with several German scientists, among others with Doebereiner in Jena who writes very often.

PARIS, DECEMBER 16, 1823

Concerning Liebig's paper on mercury fulminate, an expert opinion was given by Gay-Lussac and Dulong. At the end it reads,

". . . il reste à décrire et à étudier un grand nombre des composés salines dont l'existance ne pouvait être soupçonnée avant la découverte de Mr. Liebig. Ces divers questions seront examinées dans un mémoire dont l'auteur s'occupe.

"Ce travail très remarquable par les aperçus nouveaux qu'il renferme doit faire concevoir les plus hautes espérances du talent de son auteur."

The report is signed by Gay-Lussac and Dulong.

TO SCHLEIERMACHER, PARIS, FEBRUARY 3, 1824

It has given me the greatest pleasure that you showed so much appreciation of my research work which not only required a long time and effort, but was combined with the greatest danger to my life. I am grateful for your kind advice. I will hasten my departure which may be delayed for some time because Gay-Lussac wants to carry out some more experiments on the same object with me. I cannot reject this because the advantage for me of doing work with such an illustrious man in scientific lines is too great. Monsieur Cuvier promised to give me several fossils for you before leaving.

Because we have no real chemists in our country, I believe that my appointment will not encounter great difficulties. It would be unpleasant for me to be a burden to my parents any longer. Their sacrifices for me are already great enough. Mr. von Humboldt will have the kindness to write to you about this.

ALEXANDER VON HUMBOLDT (1769–1859) TO THE GRAND DUKE OF HESSE, PARIS, FEBRUARY 5, 1824

Monseigneur, un homme de lettres dont les voyages et les travaux ont eu le bonheur de tirer quelquefois l'intérêt bienveillant de Votre Altesse Royale ose Lui adresser une humble prière. Il la dépose avec confiance aux pieds d'un Souverain qui a fait de si nobles sacrifices pour les institutions destinées au progrès des sciences. Nous avons eu l'avantage de posséder parmi nous un de Vos sujets, Monseigneur, qui par la supériorité de son talent, les vastes connaissances en chimie et la sagacité de son esprit a vivement tiré l'attention de l'Institut Royale de France; le Docteur Liebig joint aux qualités de l'esprit cette douceur de caractère et cette aménité de moeurs qui est commune parmi les savants de son age. Si ma faible voix pourrait être de quelque poids je supplierais Votre Altesse Royale de continuer à M. Liebig les effets de sa protection particulière. Ce sera un Professeur qui honorera notre patrie et la vive reconnaissance dont je serai pénétré pour le Souverain qui daigne honorer un talent si distingué sera partagée par mes confrères a l'Académie, MM. Gay-Lussac, Thénard, Dulong et Vauquelin.

Je suis avec respect Monseigneur de Votre Altesse Royale le très humble et très obéissant et très fidèle serviteur.

le Bn. Al. de Humboldt

Another letter was added to Schleiermacher where one finds the following excerpt.

"Daignez . . . agréer en mon nom et au nom de mes confrères de l'Institut l'hommage de notre reconnaissance pour tout ce que

vous ferez pour un jeune savant qui a débuté d'une manière si brillante dans une science dont mes occupations m'ont éloignés depuis quelques années . . . . ."

On May 26, 1824, Liebig was made professor of the University of Giessen, without the faculty being asked, which was contrary to the usual practice.

TO AUGUST WALLOTH, GIESSEN, SEPTEMBER 23, 1824

They have decided to build a new laboratory. Since the barracks offered enough space, one of the annexes with columns was chosen. Before they made up their minds three months had passed, in spite of my constant urgings. Imagine three months! At this moment I am busy with the internal installation. Whether this can be finished within five weeks, only Heaven knows. But in five weeks I have to start my lectures. Imagine, for buying instruments, reagents, and materials for the laboratory, I could get a donation of one hundred florins* after great difficulties. May Heaven have mercy on me! How can I manage with so little? But I could stand all of this if only I could be spared the endless chicanery of Zimmermann (1782–1825) and his clique. They embitter my life here and spoil every pleasure. I use all my time for preparing my lectures, filing my papers, attending parties and balls, and visiting the Busch garden. This, in a few words, is what I have to add. Let me have news from you very soon, and do not punish me although I deserve it. You know that your thread of patience is a chain of iron, but mine is like a spider web.

TO SCHLEIERMACHER, BINGEN, MARCH 30, 1825

I will stay here a few days longer with Mr. Moldenhauer, and I will continue my trip to Kreuznach. I have again investigated the mother liquid of the Kreuznach brine and I find that its content in iodine exceeds considerably that of the brine of Salzhausen.

TO SCHLEIERMACHER, GIESSEN, JUNE 23, 1825

On the occasion of my analysis of the brine of Salzhausen, I have proposed to the Secretary of Finances to use the produced mother liquid for the production of hydrochloric acid and bitter salt. A short time ago I got word to build a plant at Salzhausen for hydrochloric acid and bitter salt which actually will bring the state a sum of two or three thousand florins.

TO SCHLEIERMACHER, GIESSEN, JULY 30, 1825

You will see from the enclosed prospectus that Professor Wernekingk, Umpfenbach, and I have united to establish a chemical-pharmaceutical institute. In Germany there are only two such institutions; one at Erfurt under the direction of Professor Trommsdorf; and the other in Jena, erected by Professor Göbel. The number of those who have applied every year as freshmen at the institute is so great that both can accept hardly one-sixth of them. The number of those to be accepted is fixed at twenty. I believe that we together could do much more than if one alone would direct the institute, because a personal interest will be increased considerably by a joint action. We have no doubt at all of the great success, especially since Professor Schmidt has decided to lecture on physics. For Giessen and the university this is not without fame. There will always be about twenty or thirty which will increase the number of students.

TO SCHLEIERMACHER, GIESSEN, JULY 23, 1825
(FOUR DAYS AFTER ZIMMERMANN'S SUICIDE)

The death of Professor Zimmermann was painful to us all. But this incident cannot make me blind to the good which will spring from it. Since I am here, Professor Zimmermann announced free (non-paid) lectures on chemistry. They really were not given, because the students preferred to come to my lectures on the same subjects. I believe I can rightfully apply for the regular professorship in chemistry which became free by his death.

* About forty dollars.

TO SCHLEIERMACHER, GIESSEN, FEBRUARY 16, 1826

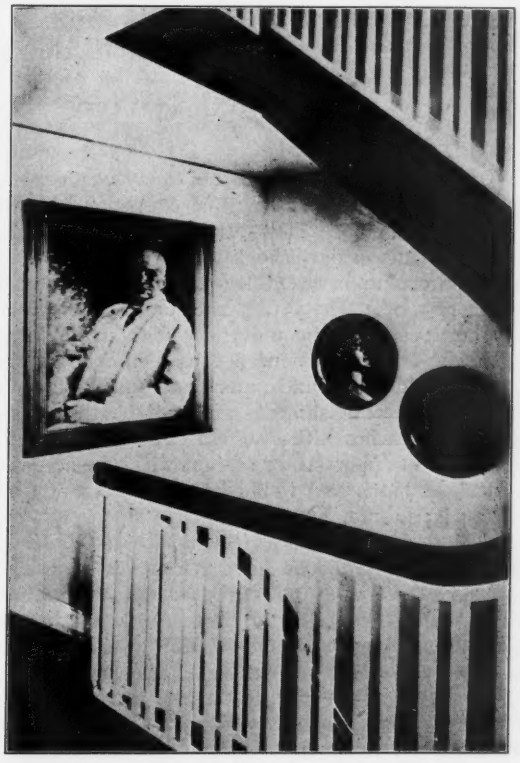
As soon as the water no longer freezes under my hands in the laboratory, I shall carry out more exactly this analysis (of the so-called "red fire,") and if you will allow it, I shall publish this in Kastner's Archiv, because I have used a new method for this analysis.

TO SCHLEIERMACHER, GIESSEN, JULY 2, 1827

My chemical institute has been supported more this year from abroad than from this country. Among my pupils are French and Dutch. I hope it will increase much more next year and that the students will be convinced that something can be learned here.

TO AUGUST WALLOTH, MUNICH, JUNE 1, 1870

The remembrance of you, my dear Walloth, is to me the clearest and purest and dearest of my youth. It would make me very happy if you could arrange to visit me here in Munich for a few weeks. Think over my proposition and if only you have a strong will you can execute it. For me it would be a gain to talk with you of bygone days, and you would learn other more intimate things about my life. I am still my old self. I cannot study just to collect knowledge in the same way as one perhaps brings timber from the woods and cuts it up in summer for use in winter time. I can do creative work only by spinning out of me the material which has been accumulated gradually in me,



PICTURE OF FRITZ HABER BY EUGENE SPIRO AND MEDALLION OF NIKODEM CARO

and only then comes the time for me to acquire all suitable matters outside of me and to use them.

Liebig, in spite of all the honors that could be bestowed on a scientist, remained a humble man. This can be seen from many of his writings and his sayings, of which one may be placed at the end of this study.

LETTER TO GRAHAM, 1852

When I reflect that whatever of good a man accomplishes flows from an inner impulse of which he is often but imperfectly conscious, and that a higher power has a part in all his labours of usefulness, giving to them their life-germ and their capacity for growth, I must own that, in receiving this noble present, I am blessed far beyond my deserts.

# *A* PLEA *for the* CREATION *of* COURSES *in* SCIENTIFIC JOURNALISM

EDGAR FRIEDENBERG*

Centenary College, Shreveport, Louisiana

THE most conservative person today would admit unhesitatingly that scientific education is progressing rapidly. New courses are being added to the curricula of our schools almost daily. The degree requirements in scientific subjects are being made ever more rigid. The young M.S. or Ph.D. in chemistry emerges from the university with much better training and greater knowledge than his counterpart of twenty years ago, and unfortunately, knows it, although his accomplishments may not be the greater for it. He reaches with insufferable assurance for the exact piece of apparatus or reagent which he needs for the task at hand, and would laugh to scorn any colleague who did not.

His horror at the chemist who uses an aldehyde when a ketone would be slightly better is almost unbounded; the tragic sight of an otherwise personable young man reaching for a Florence flask when an Erlenmeyer is indicated moves him to a mixture of tears and contempt. Never, under the greatest mental strain, would he confuse the end-point of methyl red and bromcresol blue, and his heart goes out to one who might.

But this same chemist, chuckling over the misfortunes of his fellow who has not such good technic while writing the results of his latest unpublished research, does not reach so assuredly for his tools now. Fumblingly, he secures a coördinating conjunction where only a subordinating will do, and that preposition with which he ties down a phrase has a very awkward appearance. The accurate balance with which he connected his condenser to the distilling flask does not appear in his sentence structure. And he who weighed a buffer salt to four decimal places will not weigh a descriptive adjective at all.

Should he be taxed with his inaptitude, the chemist would undoubtedly reply, "But I am not an author, only a chemist," which would be only true in a very limited sense. It is unfortunately true that most scientists are not authors, and the so-called literature which their papers cite is not of the highest quality. But they all have the responsibility of an author. When they state that they are not authors, they make, not an alibi, but a confession.

One would certainly expect that men of science would deem publication important enough to lavish a little care on the articles they release. Publication is their only possible claim on the memories of posterity. It is through publication that they assure themselves the right of prior discovery, and to publication that they appeal to make them known to their fellow scientists. Very few of them would be willing to advertise to the world at large that they are ungrammatical old bores, and yet they are willing to play just that part in the only device by which they reach an extended audience.

But perhaps the very widespread nature of this abuse contributes to its perpetuation. If all biochemists insist on a dead approach to a vital subject, there is little discredit to one who continues the method. These same chemists, however, would be among the quickest to adopt any technical improvement which came to their attention, and their failure to adopt the same viewpoint in their writings obviously constitutes an abrogation of scientific attitude.

Furthermore, it is an unjustifiable abrogation, for the advantages of writing ability to the scientist are as important as they are manifold. A scientist with a good literary style need never fear anonymity; his

* Present address: Stanford University, Stanford University, California.

researches and conclusions will rapidly become familiar to all the members of his field. With the present status of scientific literature as a background, a well-written article would stand out in any standard periodical like the single light on a one-eyed car. Good writing can never take the place of good research, but the scholar who has something to say and says it well will command attention far more successfully than one whose discoveries are couched in clumsy terms. Besides, good writing carries reciprocal privileges. Scientists are still human, and they cannot experience an emotional thrill over an article entitled "A Short Dissertation on the Effects of Alcoholic Tincture of Rotenone in the Control of Thrips on Six-weeks-old Spinach Plants in Richmond and Queens Boroughs," especially if the article concludes, as is often the case, that the tincture has no material effect on the thrips, except as it destroys their food by killing the spinach. If one scientist stops writing such articles, others will stop having to read them, and will perhaps repay in kind.

A well-written paper is also more dignified, and may easily lead to considerable financial reward for the author. Today, more than ever, there is an unsatisfied demand for popular science writing, and one which has great lucrative potentialities. The intelligent public is, as always, ready, willing, and able to pay for what it wants, and it wants information, if palatably presented. There will always be, of course, the element which prefers space ships and disintegrator rays to petri dishes and diffraction gratings, but the great majority of those who assiduously follow life on the planet Mongo do so because the pulp-fiction scientists present their matter more attractively than do the genuine article. They can hardly be blamed for so doing, but the money which these people spend on funny papers is the scientist's for the asking.

By competing for the popularized field the scientist, far from demeaning his noble calling, performs a great and necessary educational service. Most of the laymen capable of appreciating scientific advancement are now beyond the reach of formal education. By making available to them, in amusing and understandable form, the principal developments in contemporary science, the popular author certainly contributes to the total erudition of the world, but he increases the value of his researches too, as he creates a demand for their results. The consumer can buy nothing if he has not been informed of its existence, and this is equally true of medical advice and air-conditioning machines. It is equally important for the scientist to tell him that he may buy these blessings, as it is that he create them.

Since there are obviously so many advantages attached to the improvement of scientific writing methods, it would be well to investigate further the faults of the present forms, in order that they might be eradicated. There is nothing mysterious about them; in every case they are the universal faults of careless craftsmanship. Nearly all scientific articles are poorly constructed. The work is not prefaced by suitable introduction, its authors apparently preferring to hold their noses and dive into the material. No attempt is made at arranging subjects for maximum interest, and the pattern remains, for the most part, tabular, using no literary device save contrast. Brevity becomes the paramount interest of the author, with the most unfair means being put into use to secure it. Every unnecessary word is carefully burned out, and the ashes leached to make sure that only the barest skeleton is used. In a field requiring a great background, the author makes references to the work of Shapiro and Jorgenson, *et al.* (*Deutsche Bund des Sauerstoffmachens*, pp. xii-xiv), but inserts no word of recapitulation of this work. It is a great compliment to his readers, doubtless, to assume such instant familiarity with all phases of the field, but considering the sad condition of most of our vocabularies of technical foreign language, not justifiable. Certainly, we could go to the library, if we lived in a large city, and look up this issue of *Deutsche Bund des Sauerstoffmachens*, painfully translating word by word, but requiring this closes the article most effectively against all who have not the most overpowering interest in the field. Since the only reason for brevity is to save the time of the reader (paper still being cheaper than nerves) the whole practice seems inconsistent in the extreme.

The example of poor title selection given above is probably enough. Heaven knows, one cannot advocate publishing a paper on rates of solvent evaporation in air streams under the title of "Gone with the Wind," or one on the deodorant action of diethyl ketone in the breath as "How to Win Friends and Influence People," but between the two extremes there is always a more satisfactory middle ground.

Again, far too many scientists make themselves ridiculous by the ponderous masses of data which they produce. At the mid-winter National meeting of the Wilson Ornithological Society, an otherwise excellent paper on the Bird Population of Northern Ohio contained estimations of bird populations on estates and parks, calculated to three decimal places for each species. Supposedly, anyone rich enough to own an estate today would have a gardener capable of taking care of the last two decimal places before they became obnoxious, and the accuracy of such measurements is open to question anyhow. Similarly, one of the most popular first-year chemistry texts contains a table of the constituents of the entire earth (not just the crust) estimated to two decimal places on a percentage basis. The taking of an aliquot part homogeneous enough to justify such data would apparently present great difficulties, and a description of how it was accomplished would be far more interesting than the table.

Of course, there is some reason to be against anything, and revision of scientific writing methods on a basis of interest would naturally lead to loss of brevity, and in some cases perhaps, clarity, at least, if not skilfully handled. There would even be some fields where such writing would not be appropriate, in general. Laboratory directions, for instance, should never sac-

rifice explicitness at any cost. But laboratory directions are not supposed to be literature. And in an era in which even telegrams exude roseate sentiments, nothing is impossible. One of the standard texts on quantitative analysis, in its consideration of laboratory technic in filtration, states gravely that " . . . if the precipitate persists in running through, the filter paper is too coarse, or the precipitate is too fine." So perhaps there is room for improvement even here.

How is this improvement to be sought on a large scale? Interested scientists may, of course, change their methods as they see fit, but the number interested would probably be too small for appreciable changes to result in a reasonable time. The logical answer lies, with a great many others, in education.

The chemistry student, on receiving a B.S. degree, has usually had a year of physical, analytical, general, and organic chemistry, with possible extended courses in qualitative analysis of inorganic and organic compounds, biochemistry, and chemical engineering. He has had a number of auxiliary sciences, and a year of freshman composition directed toward no particular goal. Students in other sciences are comparable. Would it be unreasonable to ask for the establishment of courses in readable scientific writing in the departments in which these students major, partially or wholly satisfying the composition requirement at the option of the college? The present courses in journalism departments are not directed toward this sort of writing; at present there are no facilities for it. It would seem logical to have the course in the major department of the student, so that he could learn the art of the writing he expected to use, and not be burdened with unnecessary details of other forms. Courses are being added to the curricula of all the major colleges for no other reason than that they seem useful, and scientific journalism courses seem more useful than many others. It would certainly be an interesting experiment, with the greatest of potentialities.

It is certainly not the purpose of this paper to persuade our men of science to write like Hemingways, Sinclair Lewises, or Agatha Christies. That would be merely imitation, and in no way constructive, although possibly amusing. It is, rather, an attempt to suggest that they write like the intelligent men scientists are, instead of in the manner of a busy washerwoman compiling a laundry list.

Perhaps it seems like a waste of time, a reversion to euphemism and preciosity. If carried in the wrong direction, it would be, and that is what journalistic education would have to guard against.

But scientific journalism, correctly applied, as some of it would be, could not fail to be a step in the direction of our worthiest purpose, the increasing of the candlepower of the torch of science until it shall outshine all other beacons.

## MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMICAL EDUCATION OF THE A. C. S.

Present: B. C. Hendricks, M. V. McGill, Virginia Bartow, N. W. Rakestraw, Otto Reinmuth, Harrison Hale, O. M. Smith.

The following report of the treasurer was read and accepted:

| | |
|---|---|
| Cash on hand, September 1, 1937 | $496.80 |
| Receipts from dues | 176.50 |
| | Total $673.30 |
| *Expenditures* | |
| Office of the Secretary | $75.00 |
| Office of the Chairman | 25.00 |
| Office of the Treasurer | 5.15 |
| Abstracts | 12.02 |
| Expenses of the Dallas Meeting | 16.15 |
| Dues receipt cards | 2.50 |
| For collection of checks | .20 |
| | Total $136.02 |
| Receipts less expenditures | $537.28 |
| Outstanding checks | 31.09 |
| Cash in bank, August 31, 1938 | 568.37 |
| Cash on hand, August 31, 1938 | $537.28 |

VIRGINIA BARTOW, *Treasurer*

N. D. Cheronis was elected to the Board of Publication of the JOURNAL OF CHEMICAL EDUCATION, to succeed Tenney L. Davis.

The Chairman was authorized to appoint two representatives of the Division on the joint committee on sugar nomenclature.

It was voted to recommend to the Division the establishment of a committee on high-school chemistry.

NORRIS W. RAKESTRAW, *Secretary*

*I value in a scientific mind, most of all, that love of truth, that care in its pursuit, and that humility of mind which makes the possibility of error always present more than any other quality. This is the mind which has built up modern science to its present perfection, which has laid one stone upon the other with such care that it today offers to the world the most complete monument to human reason. This is the mind which is destined to govern the world in the future, and to solve the problems pertaining to politics and humanity as well as to inanimate nature. It is the only mind which appreciates the imperfections of the human reason, and is thus careful to guard against them. It is the only mind that values the truth as it should be valued and ignores all personal feeling in its pursuit.*—H. A. ROWLAND

# *The* DISCOVERY *of* GALVANO-PLASTY *and* ELECTROTYPING

HERBERT HEINRICH

Marquette University, Milwaukee, Wisconsin

*A close study of textbooks and encyclopedias on the subject of the discovery of electrotyping reveals a great deal of uncertainty. Most English writers mention Spencer as the discoverer, whereas German and French books give the honor to the Russian, Jacobi. Jordan, an English printer, has a much stronger claim than Spencer and yet is hardly ever mentioned. The present article clarifies the situation by reinvestigating contemporary evidence and comes to the conclusion that Jacobi has rights of priority.*

*A brief biography of this Russian scientist is included. Apparently, there exists only a Russian biography of Jacobi who was really a great scientist. Some of his major achievements are the construction of the first rotatory electric motor, the independent discovery of a constant primary cell, the laying of the first underground telegraphic line, the invention of a galvanic system for the ignition of sea mines, and so forth.*

✦ ✦ ✦ ✦ ✦ ✦ ✦

MODERN pictorial magazines are renowned for the excellence of their reproduction, their editions of a million and more copies and their low price. This modern achievement has its roots in the discovery of galvanoplasty and electrotyping which celebrates its centenary in 1938. The history of the invention is noteworthy because it affords an example of a discovery made simultaneously by several individuals. It is furthermore, an interesting human document because the contemporary press waged a bitter fight for the honor of priority, a dispute which was tainted with national partisanship and clashes between scientists and artisans. This partiality is the reason that there exists no unbiased history of this subject. It is necessary, therefore, to go back to the original literature and reweigh the evidence from an impartial viewpoint.

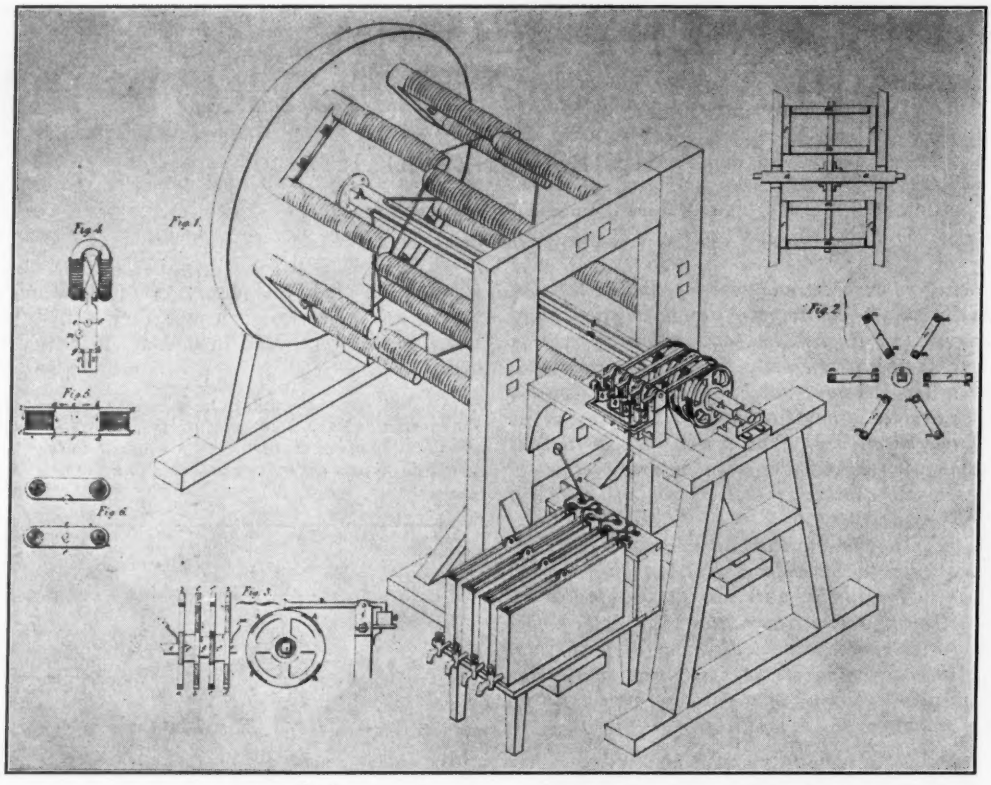
The fact that it is possible to deposit a coherent plate of copper on a copper cathode and that this plate shows in relief even the finest markings of the base metal, must have been observed a number of times by those working with the so-called "constant cell" of Daniell* who himself made this observation in 1836 but did not attach any special significance to it. In a letter to Faraday from the year 1840, Daniell writes in retrospect (*8*),

"You will remember that in my account of the construction of the constant battery [*Phil. Mag.*, p. 117, 1836] I attributed the precipitation of the copper from the sulphate to the 'deoxidating power of the nascent hydrogen'; but from the first I have been generally struck with the beautiful crystalline arrangement and close compact structure of the metallic deposit. This is so remarkable, that in the first small sheet of copper which I stripped from a platinum electrode, and which is now in my possession, I noticed that the scratches of the file, which the latter bore, were perfectly moulded upon it."

(*From Schlotke's "Die Erfindung der Galvanoplastik"*)
MORITZ HERMANN VON JACOBI (1801–1874)

A similar observation was actually published in the *Philosophical Magazine* as early as 1836 by Warren de la Rue. He observed while working with a modified Daniell cell that " . . . the copper plate is also covered with a coating of metallic copper which is continually being deposited; and so perfect is the sheet of copper thus formed, that, being stripped off, it has the counter-

* John Frederic Daniell (1790–1845), English chemist and physicist, was born in London on March 12, 1790. In 1831, he became the first professor at the newly founded King's College, London. He is known for the invention of the Daniell cell (1836), also for his dew point hygrometer, his registering pyrometer and his system of preparing illuminating gas from turpentine and resin, a system which was used for a time in New York. He died suddenly of apoplexy on March 13, 1845, while attending a meeting of the council of the Royal Society of which he became a fellow in 1833 and foreign secretary in 1839 (*18*).




(*From Taylor "Scientific Memoirs," vol. 1, 1837*)

TAYLOR WAS CHARGED TO MAKE TRANSLATIONS OF WORTH-WHILE FOREIGN ARTICLES. THIS PICTURE IS TAKEN FROM AN ARTICLE ON JACOBI'S ELECTRO-MAGNETIC MACHINE, THE FIRST ONE IN HISTORY WITH DIRECT ROTATORY MOTION

part of every scratch of the plate on which it is deposited."

However, Moritz von Jacobi not only made the observation but also saw its great practical possibilities. He announced the discovery of electrotyping and galvanoplasty in a letter to P. H. Fuss, permanent secretary of the Imperial Academy of the Sciences at St. Petersburg, dated October 4, 1838 (*1*).

". . . . . In cleaning galvanic apparatus, I noticed often that copper reduced on copper could be detached in perfectly coherent plates like the sample which I take the liberty to enclose; at the same time I noticed also that these reduced copper plates showed in relief all accidental irregularities, hammer marks, file scratches, and so forth. This was indeed very remarkable because it seemed to indicate a great calmness and constancy of this molecular reaction. It seemed, therefore, the natural thing to see how an engraved copper plate instead of an ordinary one would behave when in a voltaic combination.

"The result was, as could be expected, favorable in respect to sharpness and accuracy of the lines produced, but unfavorable in so far as it was impossible to remove the reduced plate completely from the engraved one.

". . . . . If someone should follow this subject further, I do not doubt in the least that it would be possible, to produce in this manner copper plates in relief from which one could print as from woodcuts with the advantage that the stamp could be multiplied at will for it would require only one original engraved plate.

". . . . . I wish to remark that the original should not be perfectly clean and bright, but it should be covered with an extremely thin film of fat or oil."

A more vivid and detailed account of the actual discovery is given by Moritz von Jacobi in a letter to Becquerel (*3*).

"In the summer of 1836, I performed the first experiments on the cell of the late Mr. Daniell. I used at first a construction similar to a cell recommended by Mr. Mullins the diagram of which I here attach. But this apparatus did not fulfil my purpose. I had another one constructed which is described elsewhere, where also a letter to Mr. Lenz [read in the meeting of February 3, 1837] can be found and in which I had notified this scientist of a series of experiments performed by means of this apparatus. In this letter is a passage which gives some idea of my discovery for which passage I refer to enclosure A.

"A few days after sending the letter, I looked over the cylinder belonging to the Mullins apparatus with the view of making another test. This cylinder, the outside of which was found covered with crystalline and powdery grains of copper, had to be cleaned to be covered by a new membrane. Subjecting it to this operation, my assistant detached from it some copper films, quite large, but thin and fragile. At first, I was far from attributing them to a voltaic origin. I had only begun to occupy

myself with cells using separating membranes and among the numerous questions which these interesting apparatus present to science, I was only occupied with making them as constant as possible and quite easy to manipulate in order to employ them for the motion of electromagnetic machines.

"To this day, I do not yet understand how the films mentioned above could have given me at that time the impression of having resulted in the fact that the copper of which the cylinder had been made, was perhaps poorly rolled, or that the workman not having copper thick enough had doubled the sheets.

"As a result of this impression, I called the artisan in and urged him to tell me the truth; the man accused of having served me poorly, protested to the contrary which gave me the idea of deciding the question of the origin of these films by comparing thoroughly the interior surface with the exterior surface of the cylinder. From the beginning of this examination, I saw at once some file marks, almost microscopic, but exactly identical on the two surfaces, depressed on the surface of the cylinder and raised on the surface of the detached sheet.

"Galvanoplasty became the result of this minute examination. . . . .

" . . . . . I still have the cylinder and the films of copper, objects of my first observation, but I did not note the day of the month of February of 1837, when it was made.

"In my journal I find that on March 28, 1837, I made a series of experiments to verify the law known as that of Faraday concerning the equivalence of atoms and the definite effects of the galvanic current."

The last two paragraphs seem to indicate that Jacobi wished to fix the time of the discovery between February 3, the day of the academy meeting, and March 28, the date of the entry in the journal.

The letter to Fuss which was read October 5, 1838, caused a sensation, and the president of the academy was asked to give the Emperor Nicholas a special report. The Czar not only ordered the news to be published in the St. Petersburg newspapers of December 25, 1838, but also prevailed upon the Russian Government to acquire the invention for general public use. Jacobi received twenty-five thousand silver rubles ($18,000) for it (*1*). This transaction was the reason why Jacobi frequently went to the defense of his right of priority, because he felt that it was Russia's gift to the world. The St. Petersburg articles received widespread publicity and were copied by German, French, and English papers.

The Academy of Sciences awarded Jacobi the Demidoff Prize for outstanding publication. This award caused him a great deal of trouble because he was proposed as a member of the society and at the same time practically promised the prize if he would publish his discovery. But he became a member of the academy before the publication and now was forced to attend the meetings where his work was discussed and a number of members blackballed him because it would set a precedent if a member of the awarding committee became eligible for the academic prize. Finally, Jacobi agreed to turn over the prize money of five thousand rubles to further research in galvanism and magnetism. He received the honor, but felt badly about losing the money.

The news of the discovery reached the French paper *Débats* on February 11, 1839 (*3*); one of the earliest British accounts appeared in the Athenaeum of May 4, 1839 (*5*).

"While M. Daguerre and Mr. Talbot Fox have been dipping their pencils in the solar spectrum, and astonishing us with their inventions, it appears that Professor Jacobi, in St. Petersburg, has also made a discovery which promises to be of little less importance to the arts. He has found a method—if we understand our informant rightly—of converting any line, however fine, engraved on copper into relief, by a galvanic process. The Emperor of Russia has placed at the Professor's disposal, funds to enable him to perfect his discovery."

This paragraph was copied in the *Mechanics' Magazine* of May 11, 1839 (*17*), where on June 8 the following letter was printed signed by C. G. Jordan, a young printer from London.

"Observing on the last page of a recent number of your magazine a notice extracted from the Athenaeum, relative to the discovery of Prof. Jacobi, its perusal occasioned the recollection of some experiments performed about the commencement of last summer with the view of obtaining impressions from engraved

(*From The Eclectic Magazine, vol. 26, 1852*)
NICHOLAS I, EMPEROR OF RUSSIA (1796–1855)

copper plates by the aid of galvanism, which led me to infer some analogy in principle with those of the Russian professor, and may probably give me the right to claim priority in its discovery and application.

"These experiments were abandoned from the want of that most important element in pursuits of this nature—time; the writer's share of the said element being occupied in a manner more imperative than pleasing. I regret, however, not having made it the subject of an earlier communication, as this would have placed my pretentions beyond doubt; but inasmuch as the notice alluded to is given from memory, and is undescriptive, whilst I

may be enabled to exhibit the modus operandi, my assertion may be at least partially substantiated."

After a detailed description of the apparatus Jordan continues.

"In some experiments of this nature, on removing the copper thus formed, I remarked that the surface in contact with the plate equalled the latter in smoothness and polish, and mentioned this fact to some individuals of my acquaintance. It occurred to me, therefore, that if the surface of the plate was engraved, an impression might be obtained. This was found to be the case. . . .

". . . a common printer type was substituted for the copper plate, and treated in the same manner. This also was successful. . . .

". . . . . It appears, therefore, that this discovery may be turned to some practical account. It may be taken advantage of in procuring casts from various metals, as above alluded to; for instance, a copper die may be formed from a cast of a coin or medal, in silver, type-metal, lead, etc., which may probably be obtained from a plaster surface surrounding a plate of copper; tubes or any small vessel may also be made by precipitating the metal around a wire or any kind of surface to form the interior, which may be removed mechanically, by the aid of an acid, or by heat."

(*From Ahrens' "Briefwechsel zwischen C. G. J. Jacobi und M. H. Jacobi"*)

CARL GUSTAV JACOBI (1804–1851)

PRIVATDOCENT IN MATHEMATICS BERLIN 1820, TRANSFERRED TO KÖNIGSBERG, EAST PRUSSIA, WHERE IN 1827, HE BECAME EXTRAORDINARY AND TWO YEARS LATER ORDINARY PROFESSOR. HE PUBLISHED PAPERS ON THE THEORY OF ELLYPTICAL FUNCTIONS, DIFFERENTIAL EQUATIONS AND THEORY OF VARIABLES. HE WAS A MEMBER OF MANY LEARNED SOCIETIES. HE DIED IN 1851, THE VICTIM OF AN EPIDEMIC

The announcements of Jacobi and Jordan are given in detail because the right of priority must in the final analysis be decided on the date and content of the respective publications. Postponing for a time the weighing of the evidence, it is interesting to trace the history of galvanoplasty into the next phase. Apparently Jordan's article made no impression on the interested parties. It was disregarded so thoroughly that five years later an outsider had to remind the editor of the *Mechanics' Magazine* that Jordan's article had appeared in that journal.

In September, 1839, there was published in the *Philosophical Magazine* (*15*) a letter by Jacobi addressed to Faraday in which he described among other things his method of galvanoplasty. This letter was accompanied by the negative and the positive of a medal, together with the original which was partially covered with a second negative adhering so strongly to the medal that it could not be removed. Jacobi also promised Faraday a galvanic reproduction of an original made of non-conducting material. This letter was reprinted in the Athenaeum and drew the following comment.

"Our notice last week of the discovery of Dr. Jacobi of a method of making copies in relief of copperplate engravings by means of electro-magnetism, has induced Mr. Spencer, of Liverpool, to forward us an interesting statement, and several specimens, in proof, that he not only made a like discovery, but has actually practiced it. We shall bring the subject under consideration next week.

"MR. SPENCER GIVES PARTICULARS OF HIS PROCESS

"We have since received a communication from Mr. Thomas Spencer of Liverpool, from which it appears that that gentleman has for some time been independently engaged on the same subject; and that he has not only succeeded in doing all that Mr. Jacobi has done, but has successfully overcome those difficulties which arrested the progress of the latter. It is unnecessary here to enter on the question of priority between these gentlemen. To Mr. Spencer much credit is due for having investigated, and successfully carried out an application of the voltaic electricity, the value of which can hardly be questioned. The objects which Mr. Spencer says he proposes to effect, were the following. 'To engrave in relief upon a plate of copper, to obtain a facsimile of a medal, reverse or obverse, or of a bronze cast—to obtain a voltaic impression from plaster or clay and to multiply the number of engraved copper plates.'"

Thomas Spencer of Liverpool was quite a colorful character. By profession a "humble carver and gilder," he dabbled in science and pseudo-sciences. His versatile mind was attracted to the spectacular as indicated by some of his papers read to the local scientific societies. His lectures covered such subjects as the theory of heat, the ossification of animal remains, the formation of peacock ore and native copper, geological stratification, mesmerism* and galvanism

* Spencer's paper "On some Recent Instances of Clairvoyance' was read at the Royal Institution in Liverpool before the Literary and Philosophical Society. Parts of the paper are interesting as they reveal the character of the author. The medium, a Scotch woman, Mrs. Isabella Todd, described, unseen, Spencer's shop and laboratory with dishes on table and floor and the space littered with "papers full of scribbles." To test Mrs. Todd's power, Spencer went into an adjoining room and struck the following significant pose. "I put my thumb to the tip of the nose and extended the fingers outwards in the most approved manner, and as we frequently see enacted by the clown in the ring. I remained in this dignified attitude for some time" (*17*).

From his writings and the opinion of contemporaries we glean that he must have been an arrogant, ambitious person who was not any too careful of the rights of others and who was feared in his own circles for the sharpness of his retorts.

Spencer's part in the discovery of electrotyping is quite typical of his other endeavors. According to his own accounts (*21*), he had been working for some time when in May, 1839, he announced in a letter to the Liverpool Polytechnical Society that he had discovered a method of duplicating objects by galvanism and that he would disclose his discovery at his earliest convenience. This letter to the Society came four days after the first report of Jacobi's discovery in the Athenaeum. Then nothing was heard from Spencer for four months when he applied and received permission to address the British Society for the Advancement of Science. The permission was later withdrawn, apparently because the officers of the Society felt that his results were not trustworthy. So Spencer left Birmingham in a huff and delivered his lecture to the Liverpool Society on September 12, 1839. The organization published Spencer's results for free distribution.

In contrast to Jordan's earlier article, the news of Spencer's discovery took the country by storm and the "humble carver" found himself famous overnight. The newspapers and especially the popular scientific magazines became champions of his cause while the scientific journals were rather cold to his claims.

However, not all practical men supported Spencer. Gustav Jacobi, the famous mathematician and younger brother of Moritz, writes from a trip through England (*1*),

". . . . . You had an entirely mistaken idea that Manchester is the headquarter of your enemies. Quite the contrary, everybody is full of enthusiasm for you and at Joseph Lockett's, engraver for calico printer, in whose country-house we lived, we drank almost daily to your good health. . . "

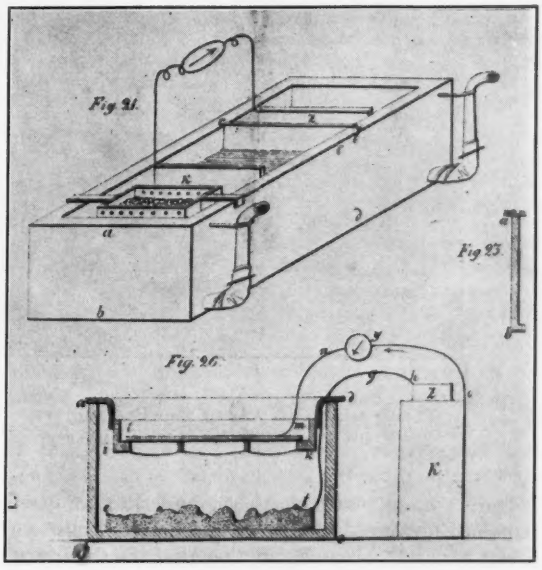
But the popular press backed Spencer's claim, nevertheless, and some went even so far as to ask for a grant of several thousand pounds to be given to Spencer so that he might have equal opportunities with Jacobi. This whole situation put Jacobi in an awkward position. The controversy came to a head when Jacobi attended the meeting of the British Society for the Advancement of Science at Glasgow to deliver a lecture on his new electro-magnetic machine (*7*). When Spencer and Jacobi met at this meeting a sharp dispute ensued, Spencer apparently* basing his claims on the insufficient data given in the short notice published in the Athenaeum and on Jacobi's inability to devise a method which would ensure the removal of the electroplate from the original (see letter to Faraday).

Jacobi, however, insisted that it was unfair to judge his process by a short newspaper excerpt and that (*3*)

". . . he was forced to reveal the poor grace with which Mr. Spencer had intended to use the interesting fact to the detriment of my claims."†

Contemporary evidence seems to support Jacobi. In the Glasgow Argus, No. 795, September 24, 1840 (*1*), we find,

"The chairman said, the public looked upon priority of publication as establishing a claim to priority of discovery; but he had no doubt that both gentlemen had made the discovery quite independent of each other."




(*From Jacobi's "Die Galvanoplastik"*)
TWO TYPES OF APPARATUS USED BY JACOBI (1840)

Then, again, in the Athenaeum of October 24, page 846, 1840:

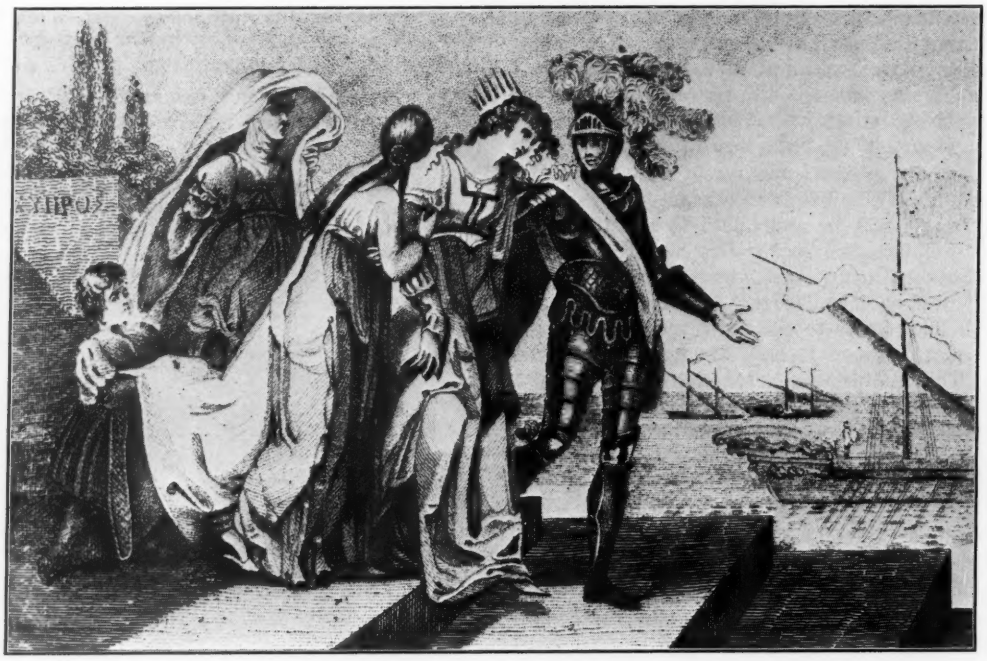
". . . . . He [Spencer] did not, however, publish an account of them till 1839, so that Professor Jacobi is undoubtedly entitled to the claim of priority of discovery, as far as publication is concerned, which usually determines the question."

The French view is summed up by Becquerel who adopted the point that Jacobi did not only publish the earliest account but that his description was complete enough to establish his priority (*6*).

These expert testimonies should have been enough to settle the claims of priority in favor of Jacobi, but the popular press refused to accept the verdict. As late as 1867, exactly thirty years after the discovery, Becquerel published a letter by Jacobi from the year 1846, in which the Russian scientist deplores bitterly the deliberate boycott of his name by the British popular press and again lays before the public the facts of the discovery (*3*).

* A careful perusal of the minutes of the Glasgow meeting fails to reveal any official discussion of the controversy. The proceedings contain however, a statement by Jacobi that there is a misprint in 'Galvanoplastik' as to the date of the letter to Fuss. It not being October 5, 1839, but 1838.

† It seems evident that Jacobi refers to the remarkable degree of adhesion between electroplate and original which he considered in his letter to Fuss to be due to "plastic molecular action" similar to smelting.



(*from the Annals of Electricity, September, 1840*)

THIS IS A LITTLE-KNOWN EARLY ELECTROTYPE. STURGEON BELIEVED IT TO BE THE FIRST ONE IN ENGLAND, BUT THE LITTLE REMBRANDT COPY IN THE LONDON JOURNAL PRECEDES THE ABOVE ELECTROTYPE BY A FEW MONTHS

During these years the earlier publication of Jordan remained unnoticed until in 1844, Henry Dircks* published a series of articles in the *Mechanics' Magazine* (*17*) in which he supported Jordan's claim to the discovery over that of Spencer. These articles are interesting, both as examples of a vigorous scientific controversy and as human documents. Spencer's replies reveal him as a person who asserts facts and deals in generalities. But in Dircks he found an opponent who could not be intimidated and put off with phrases.

In brief, Dircks claimed and supported by unrefuted facts that Spencer appropriated the essential features of his so-called invention from the ideas of different people; the plaster of Paris cell from Golding Bird who gave a lecture in Liverpool; the porous cup from Dancer, an instrument maker and an acquaintance of Spencer; the application of the relief markings on an electroplate to the broad hints given in the notice of Jacobi's discovery in the Athenaeum and Jordan's description of his experiments, together with some personally communicated experiments of Dancer. At best, therefore, Spencer had only a claim to the improvement and not to the actual discovery.

Dircks advances the theory that Spencer even made use of phrases similar to those employed by Jordan. According to Dircks, a misprint in the latter's article gave Spencer the idea for a new application of galvanoplasty. Jordan wrote,

"... *tubs* or any small vessel may also be made by precipitating the metal around a wire or any kind of surface to form the interior, which may be removed mechanically, by the aid of an acid solvent, or by heat."

It is evident from the context that *tubs* should have read *tubes*. But Spencer (according to Dircks) took the misprint to be correct and developed a method to plate the hulks of model ships with copper.

Spencer's replies to the accusations are wordy, but devoid of refuting evidence. With each reply, Spencer's language becomes increasingly more abusive. He calls Dircks a slippery customer, a liar, a meddler, a seeker of personal glory. Surprising enough is the speed with which the editor of the *Mechanics' Magazine* who had enthusiastically supported Spencer dropped him and actually attacked him in the editorials which frequently followed the polemics of Dircks and Spencer.

Dircks sent copies of his articles to leading scientists. Professor Brande, then chemist to the mint, made an interesting comment (*19*).

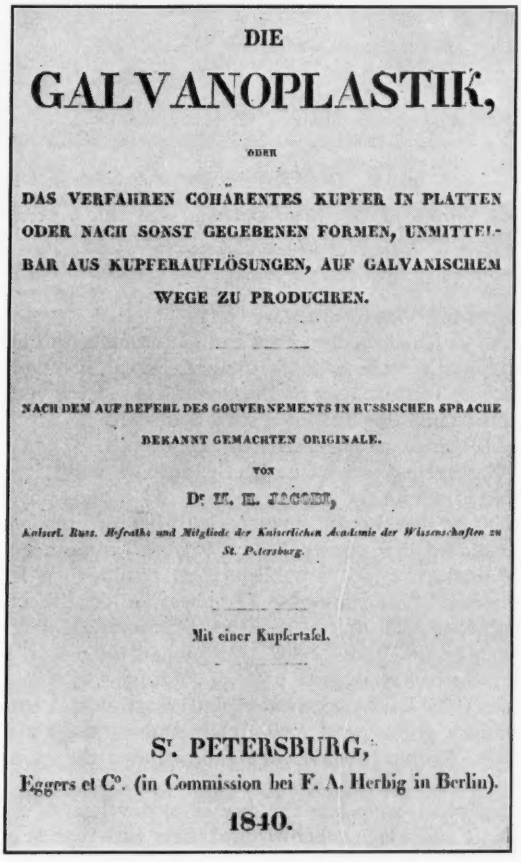
"I am much obliged by your copy of the *Mechanics' Magazine* and the information it contains respecting Mr. Spencer's pretentions. I certainly always gave him credit for much more merit than he appears to have deserved."

* Henry Dircks (1806–1873), civil engineer, author of scientific and poetical books was born in Liverpool. For a time he was in the manufacturing business but later gave it up to become a consulting engineer. During this time, he made a number of patentable discoveries and wrote serveral historical books and treatises. In 1837, he became a life member of the British Association (*9*).

Michael Faraday commented as follows (*19*).

"I am very much obliged by your kindness in sending me your account of the facts, etc. It is very valuable as respects the fixing of dates, and has rather surprised me."

In spite of these crushing denunciations, Spencer was already too well entrenched in the public mind and, for that reason, we find textbooks and encyclopedias either omitting Jordan's name entirely or just barely mentioning it. In 1852, Dircks (*10*) made another unsuccessful attempt to establish Jordan's claim by publishing a small pamphlet entitled "Jordan-type, otherwise called Electrotype."



DIE

GALVANOPLASTIK,

ODER

DAS VERFAHREN COHÄRENTES KUPFER IN PLATTEN ODER NACH SONST GEGEBENEN FORMEN, UNMITTELBAR AUS KUPFERAUFLÖSUNGEN, AUF GALVANISCHEM WEGE ZU PRODUCIREN.

NACH DEM AUF BEFEHL DES GOUVERNEMENTS IN RUSSISCHER SPRACHE BEKANNT GEMACHTEN ORIGINALE.

VON

Dr M. H. JACOBI,

*Kaiserl. Russ. Hofrathe und Mitgliede der Kaiserlichen Academie der Wissenschaften zu St. Petersburg.*

Mit einer Kupfertafel.

S<sup>t</sup>. PETERSBURG,

Eggers et C<sup>o</sup>. (in Commission bei F. A. Herbig in Berlin).

1840.

(*From Ahrens' "Briefwechsel zwischen C. G. J. Jacobi und M. H. Jacobi"*)

TITLE-PAGE OF M. H. JACOBI'S "DIE GALVANOPLASTIK"

The next question which has to be settled in this conflict of rights of priority is whether Jordan or Jacobi can claim precedence. There was never an actual dispute between the two men and, therefore, the present analysis will apparently be the first one ever attempted on this subject. Jordan bases his claims on his publication in May, 1839, in which he gives the "modus operandi" of electrotyping without knowing any details of Jacobi's process. On the other hand, Jacobi lays claim to the invention by right of his earlier publication, his letter to Fuss on October 5, 1838. He counters the argument of his opponents that he did not realize from the beginning the importance of his observation, by two letters of colleagues at the University of Dorpat (*1*).

"I, the undersigned, testify herewith that I was one of the first persons, who was notified of this interesting discovery of galvanoplasty. Namely in the spring of 1837, the academician councilor Jacobi showed me a very well-executed plastic impression of a Russian copper coin which he had obtained by a galvanic process. I recollect that at this occasion I called the attention of Mr. Jacobi to the danger which he could run making impressions of Russian coins. We both did not realize to what important results this first beginning would lead.

Professor, Councilor C. Claus of Kasan*

"It is a pleasure to certify this above testimony of my friend Claus. I, too, saw in the spring of 1837 the method by which Mr. Jacobi, then professor in Dorpat, could produce by galvanism the first impression of a two Kopecks piece and I also recall a remark by Mr. Jacobi that this process was capable of considerable technical development, a prediction which was fully justified.

St. Petersburg,
January 5, 1842

Dr. Ernst Hoffmann†
Councilor and Professor at the
St. Wladimir University at Kiew.

In his article, Jordan reported the successful deposition of copper on printer's type and engraved copper plates. Jacobi formed impressions of medals, coins, and engraved plates. In addition, he reported the remarkable strong adherence of the plate to the original and suggested a thin film of fat or grease to prevent it. Furthermore, he studied different modes of deposition. Therefore, it seems that on the count of actual achievements, Jacobi again emerges a victor.

Jordan began his experiments in the early summer of 1838, Jacobi had his first results in March, 1837, continuing his work intermittently, he culminated it by the publication of October 5, 1838. It took that much time because Jacobi was fully occupied by order of the emperor with the development of the electromagnetic motor and yet realizing the importance of galvanoplasty he found time to develop the new art. This is in contrast to Jordan who in his own words discontinued experimentation for lack of time in spite of being aware of the importance of his discovery.

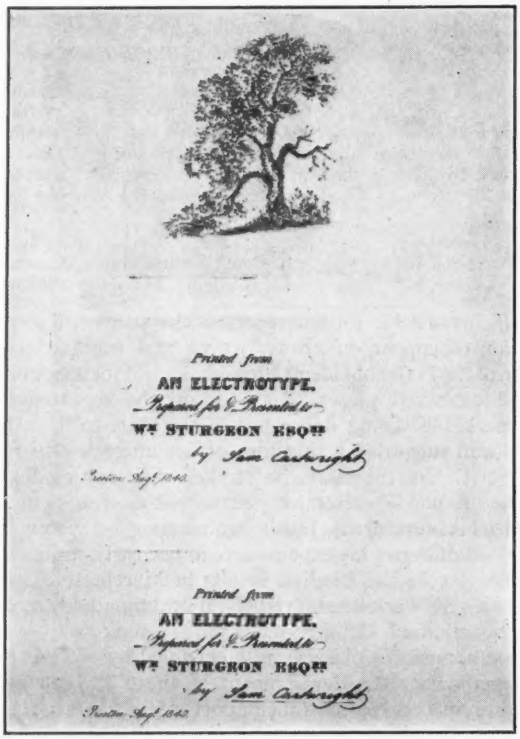
* C. Claus (*23*), pharmacist, biologist, and chemist was born in 1796. At the age of twenty-one he took charge of a pharmacy in Saratov located on the steppes of the Volga in order to have the opportunity to study fauna and flora of this little-known region.

In 1831, he returned to Dorpat to the modest position of an assistant in chemistry to be able to devote all his time to the pursuit of science. After receiving his Master's degree, he went as adjunct to the University of Kasan where his scientific ability and zeal was recognized and soon rewarded. While in Kasan, Claus studied the waste products of the platinum refineries and, in 1844, he found in them a new element of the platinum group, ruthenium. In 1852, Claus returned to his native city Dorpat as head of the Pharmaceutic Institute, at that time the only one in Russia. He died in 1864 while actively engaged in writing an extensive monograph of the platinum metals, material for which he had collected on a trip through western Europe.

† E. Hoffmann (*3*) was (1846) a colonel in the Engineering Corps.

Summing up the evidence, it is apparent that Jacobi has rights of priority for the invention of galvanoplasty and electrotyping although Jordan made the discovery without knowing of Jacobi's work.

The invention of electrotyping and galvanoplasty is so simple both in principle and equipment that one is not surprised to learn that it was adopted immediately by industry and the arts. As early as 1839, the Russian government used electrotypes to print documents (*13*). The diffusion of knowledge was helped considerably by pamphlets published by both Jacobi and Spencer. Even today no better instructions can




(*From the Annals of Electricity, September, 1840*)

THIS IS A LITTLE-KNOWN EARLY ELECTROTYPE. STURGEON BELIEVED IT TO BE THE FIRST ONE IN ENGLAND, BUT THE LITTLE REMBRANDT COPY IN THE LONDON JOURNAL PRECEDES THE ABOVE ONE BY A FEW MONTHS

be found. Apparently, the first published British electrotype appeared in the *London Journal* (*16*) of April, 1840.

Here in America, the pioneer is Joseph Alexander Adams* (*14*), a wood engraver who found it convenient to preserve his best woodcuts by electrotypes. The one here shown is by Adams and was published April, 1841, in the American Repertory (*2*).

* Joseph Alexander Adams (1803–1880) was born in New Germantown, Hunterdon County, New Jersey. A printer by trade, he taught himself wood-engraving, made several trips to Europe to improve his art. He became one of the best artists in his speciality. Adams is well known for the 1600 wood cuts which he made for Harper's Illustrated Bible (1843). He later gave up wood-engraving as a profession and devoted his time to the pursuit of science.

### MORITZ HERMANN VON JACOBI

Moritz Hermann von Jacobi was born September 21, 1801, the son of a banker in Potsdam near Berlin, Germany. At the wish of his parents, he studied architecture in Göttingen and later entered the gov-

(*From the American Repertory, April, 1841*)

PROBABLY THE FIRST ELECTROTYPE EVER PUBLISHED IN THE UNITED STATES. THE ORIGINAL AND THE ELECTROTYPE WERE PREPARED BY JOSEPH ALEXANDER ADAMS, A WELL-KNOWN WOOD ENGRAVER OF THAT TIME

ernment service of his native city. In 1833, he transferred to Königsberg in East Prussia where his brilliant brother, the famous mathematician Karl Gustav was teaching mathematics at the university. Here Jacobi spent stimulating and interesting hours with his brother and his circle of congenial academic friends. The time in Königsberg proved to be the turning point in his career, because the studies in pure and applied physics which he here began, financed with his own moderate means, led him eventually away from the practice of architecture. Jacobi published his results in a little pamphlet "Mémoire sur l'Application de l'Electromagnétisme au Mouvement des Machines" (1835), in which he describes a new electromagnetic motor, the first one in history with a direct rotatory action.

In 1835 Jacobi received a flattering offer as extraordinary professor of civil-architecture at the University of Dorpat, Russia. Thus he entered the country which was destined to become his second home and the place which gave him the chance to develop his great talents and which acknowledged them with high honors and rich financial returns. Here in Dorpat, he lived up to his nickname the "indefatigable Jacobi" because besides his lectures and his duties as practicing architect, he found more and more time to devote to his electrical investigations. These were primarily directed toward the construction of a constant galvanic cell because Jacobi realized that without such, his electromagnetic machine would be useless. According to Ostwald (*18*), he discovered independently the constant galvanic cell, but did not publish his results soon enough. Jacobi seems to have had a clearer conception of the operation of a galvanic cell than Daniell who believed for sometime that sulfuric acid was essential,

whereas Jacobi used from the first different kinds of solutes and recommended neutral salts to suppress chemical action and limit corrosion to galvanic forces.

These experiments on the constant galvanic cell led accidentally to the discovery of galvanoplasty which had not only great popular appeal but also made his name well known in the scientific world. This esteem of his fellow scientists was quite gratifying to Moritz von Jacobi because there is little doubt that he felt somewhat depressed and even jealous of the fame of his younger brother. Moritz did not like to be "the brother of the celebrated geometer." He must, therefore, have been very pleased after the publication of his "Galvanoplastik" (*12*), to receive from the world-famous Alexander von Humboldt this congratulatory letter (*1*).

"The paper has the merit of greatest clarity and noblest simplicity of presentation. The circle of technical applications of your neat, well conceived discovery has widened most remarkably; even those who in the beginning seemed to doubt a general practical application realize their errors and render full justice to the galvanoplastic process. Such a discovery is, however, not only important for that which it creates immediately, but also for that fact that as an enlivening principle, as a means for the diffusion of knowledge through a class of people that till now, were not reached, such a discovery demands by the so-called lower classes as well as by the large better class mob (Pöbel) the admiration for those men who find the useful while searching for the truth. The discovery teaches that knowledge is power."

While these experiments were still in progress, Jacobi followed a call to St. Petersburg where Emperor Nicolai Pawlowitsch was developing a scientific center by attracting scientists from all Europe. Here in the capital of Russia began for the ambitious Jacobi a time of intensive and varied activities in which his inventive and organizing abilities developed freely. To show the energy with which he attacked his work a part of a letter (*1*) may be quoted.

"Holy days become the only days of rest because I have installed at my home a mechanic's workshop where four persons are constantly at work to build apparatus and instruments for my own work or other purposes. Although I always had one mechanic in my house, I used him only to assist me or to make changes on my apparatus."

The emperor was especially interested in the development of the electromagnetic motor for the propulsion of boats. In accordance, Jacobi built a number of electrically powered vessels, one of the most efficient being twenty-eight feet long carrying fourteen people at three miles per hour. This boat was powered with sixty-four cells of platinum and zinc electrodes in a mixture of nitric and sulfuric acids. The total surface of the platinum electrodes was over eleven square feet (*7*). The reports of the successful experiments found widespread publicity even as far as the United States.

These tests were seriously hampered by the lack of experienced workmen and the presence of high officials. In a letter to his brother, Jacobi writes (*1*),

". . . . .Experiments, on which much depends, the calculation of which rest on knife's edge, in the presence of highest persons, on the roaring sea, to perform with the same exactness and poise as in the quiet laboratory is not easy. Archduke Michael sometimes feels my pulse to see if it runs feverish. But sometimes, I am like the gambler who calls his 'va banque' perfectly at ease."

Then again in a letter to the physicist, H. W. Dove, he writes humorously of his desperation on board when the entire supply of sulfuric acid was spilled, the cells leaked, a dumb mechanic stood by helplessly, and to top it all rain and storm and a public waiting for results.

The two inventions, galvanoplasty and the electromagnetic motor made Jacobi's name known all over Europe. When his younger brother made an extensive trip through various countries, he "caused real regret

(*From Ahrens' "Briefwechsel zwischen C. G. J. Jacobi und M. H. Jacobi"*)

MORITZ HERMANN VON JAÇOBI (1801–1874)

that he was not the 'famous' Jacobi." This mix-up between the two brothers even crept into the standard encyclopedias when Karl Gustav Jacobi was credited with the discovery of galvanoplasty.

Jacobi pioneered also the field of the telegraph and in 1843 he laid the first underground line between St. Petersburg and Zarskoje Selo. Here again, handicapped by unreliable help, he had to inspect personally over thirty-three miles of wire. As Jacobi became once impatient about constant difficulties, the emperor himself quieted him with the words "Gradatim, gradatim magice" (*1*).*

*When Jacobi was elevated to hereditary nobility (1850), he included the word "Gradatim" in his code of arms.

In addition, he had trouble with narrow-minded officialism and in 1848, he terminated in disgust his connections with the telegraphic bureau of the Moscow railroad.

Like many other inventors, Jacobi did not publish all his inventions. From his correspondence with his brother, we learn that he spent the summer of 1844 in the development of a galvanic ignition system for seal mines which worked out very satisfactorily and increased his yearly salary by 2000 silver rubles ($1440). This invention proved its worth in the successful defense of the harbor of Cronstadt in the Crimean War (1854–56).

*(From an engraving by D. J. Pound)*

BARON ALEXANDER VON HUMBOLDT (1769–1859)

NATURAL PHILOSOPHER, TRAVELLER, HE WAS ACQUAINTED WITH PRACTICALLY EVERY CONTEMPORARY SCIENTIST OF NOTE. ONE SAYS OF HIM THAT HE WAS THE LAST PERSON IN HISTORY WHO HAD THE GRASP OF ALL KNOWLEDGE. AT THE TIME OF THE DISCOVERY OF GALVANOPLASTY HE RECEIVED FROM FIFTEEN HUNDRED TO EIGHTEEN HUNDRED LETTERS YEARLY. IN HIS WRITINGS HE COMBINED CLASSICAL VIEWPOINTS WITH THE RISING EXACT SCIENCES

Jacobi's work on the transmission of electricity over long distances impressed on him the need of better knowledge of conductance through wires and he developed methods and equipment to measure resistances, independently of Wheatstone in England. The instruments of the two men are surprisingly alike, but there can be no doubt about their independent efforts (*18*). In 1848, Jacobi sent definite lengths of copper wire to leading physicists in Europe to serve as standards of resistance. Later these standards lost their usefulness by the definition of the ohm, and also by the fact that Jacobi's units varied either because they were not carefully calibrated or changed with time.

The idea of international standards was always uppermost in his mind. In the year 1867 he was the Russian delegate and the president of the international committee for the establishment of international units of weight, measure, and money. He also advocated the creation of accurate primary standards. Because of his efforts, a convention of experts from seventeen European and American countries was called to decide on basic principles for future work.

Of far-reaching importance were his large scale experiments with electric and gas lights (*20*) which he undertook together with Augeraud. Working continuously without regard for his physical welfare, Jacobi's health began to fail as early as 1870. The symptoms of a serious heart disorder showed up again on his return from a trip to Paris which he had made in the interest of international units. His strong constitution rallied several times, but each time Jacobi became weaker, succumbing March 10, 1874.

Moritz von Jacobi was a person of high ambitions, great talents, and unbound energy for work. Of quick temper and rash words which he later regretted, he did not make friends readily, but the friends whom he did make, valued his great loyalty and sincerity for the cause of science. He had the knack of translating theoretical discoveries into practical achievements. His one hundred-thirty three publications as cited by Ahrens deal in addition to the major subjects with a great variety of topics such as: how to improve meteorological observations; an alcohol hydrometer; absorption of hydrogen by iron; a galvanic pendulum clock; lightning arrester for powder magazines, and so forth.

It was his misfortune, to live in a period of rapid development in the field of galvanic electricity and, therefore, many of his discoveries were made simultaneously by others who today receive the sole credit because they happened to live in countries where dissemination of knowledge was easier. But there seems to be no doubt that Moritz von Jacobi should be ranked with the best of his contemporaries.

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# ATOMIC STRUCTURE *and the* PERIODIC TABLE

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THERE are two chief purposes in all scientific endeavor. The one is to secure accurate knowledge. The other is to interrelate the various items of that knowledge through the establishment of progressively unifying principles. The degree of maturity of any science may be quite accurately judged by the extent to which the tested knowledge within its domain has been organized and integrated.

To one who has had experience in teaching both chemistry and physics as elementary courses on the secondary level, it is clearly apparent that the older science, physics, exhibits the greater maturity. We must admit that much of what we teach in general chemistry in secondary schools is still purely descriptive and empirical, not interpretive and theoretical. There are those who contend that the adolescent mind is better adapted to the understanding of simple descriptions of natural phenomena than to the comprehension of organized theoretical knowledge. They suggest that the content of our science courses should stress descriptions at the expense of theory. If we follow their suggestion, however, we may no longer rightly call our courses "science." For they do not provide the sort of essential experience in rigorous, abstract thinking which educators had in mind when they made a year's course in science a requirement for high-school graduation. They do not reveal to the student the beauty and power of organized knowledge which has made this age truly an age of science.

Therefore, those of us who are interested in teaching chemistry as a *science* should lose no opportunity to advance its integration, not only because such integration will give the beginning pupils a truer concept of the *science* of chemistry, but also because it will simplify the student's problem of understanding and remembering the facts taught.

It is obvious that the concept which has the greatest integrating potentialities for chemistry is that of atomic structure. When we clearly understand the structure, motions, and forces within the atom we will have a

basis for a unified explanation of all chemical phenomena. Rapid progress has been made in understanding the atom, and that progress has been reflected in many textbooks of elementary chemistry. The purpose of this article is to suggest a way in which the periodic table and its interpretation may be clarified by a closer correlation with the fundamental concepts of atomic structure.

As commonly taught at present, the periodic law is related only incidentally to atomic structure. But since the law deals essentially with the properties of

SYNOPSIS OF ATOMIC STRUCTURE

| Orbits / Electrons | K | L | M | N | O | P | Q |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 3 | 11 | 19 | 37 | 55 | 87 |
| 2 | 2 | 4 | 12 | 20 | 38 | 56 | 88 |
| 3 | | 5 | 13 | 31 | 49 | 81 | |
| 4 | | 6 | 14 | 32 | 50 | 82 | |
| 5 | | 7 | 15 | 33 | 51 | 83 | Level 1 |
| 6 | | 8 | 16 | 34 | 52 | 84 | |
| 7 | | 9 | 17 | 35 | 53 | 85 | |
| 8 | | 10 | 18 | 36 | 54 | 86 | |
| 9 | | | 21 | 39 | 57 | 89 | |
| 10 | | | 22 | 40 | 72 | 90 | |
| 11 | | | 23 | 41 | 73 | 91 | |
| 12 | | | 24 | 42 | 74 | 92 | |
| 13 | | | 25 | 43 | 75 | | |
| 14 | | | 26 | 44 | 76 | | Level 2 |
| 15 | | | 27 | 45 | 77 | | |
| 16 | | | 28 | 46 | 78 | | |
| 17 | | | 29 | 47 | 79 | | |
| 18 | | | 30 | 48 | 80 | | |
| 19 | | | | 58 | | | |
| 20 | | | | 59 | | | |
| 21 | | | | 60 | | | |
| 22 | | | | 61 | | | |
| 23 | | | | 62 | | | |
| 24 | | | | 63 | | | |
| 25 | | | | 64 | | | |
| 26 | | | | 65 | | | Level 3 |
| 27 | | | | 66 | | | |
| 28 | | | | 67 | | | |
| 29 | | | | 68 | | | |
| 30 | | | | 69 | | | |
| 31 | | | | 70 | | | |
| 32 | | | | 71 | | | |

the atom, and since the properties of the atom are determined by atomic structure, the relationship between periodic law and atomic structure should be more than mere incidental correlation. Atomic structure can be used to explain, in part, at least, the *why* of the periodic law.

Furthermore, there are at least two complications in the usual periodic table which present difficulties to the beginning student. The first complication is the presence of the long periods, which necessitates the placement of dissimilar elements in the same group and the introduction of two families in a group. The second complication is the presence of the rare earth elements, which are placed in a separate table and lamely explained away as having no place in the periodic table. Atomic structure can be made the basis of a revised periodic table which avoids these complications.

If we arrange the atoms in the order of their increasing atomic numbers we observe that each atom has one more extranuclear electron than the one preceding it. Paying particular attention to this single electron which distinguished any atom from the one preceding it, and which might therefore be called the differentiating electron, we see that its placement seems to follow certain general tendencies which may be expressed in the following laws.

*The Law of Capacity.*—The maximum number of electrons which can normally occupy any given orbit is given by the simple formula $2 \times n^2$, where $n$ is the orbit number, counting outward from the nucleus. That is, for the $K$ orbit, $n$ is 1; for the $L$ orbit, $n$ is 2, and so forth.

*The Law of Symmetry.*—The orbital electrons tend to be distributed symmetrically among the various orbits. The greatest number of electrons is usually found in an intermediate orbit, with decreasing numbers in the orbits to the outside and to the inside.

*The Law of Consistency.*—For atoms of successively increasing atomic number, the additional electron tends to be placed in the same orbit as the one preceding it until the orbit is filled to capacity, or until a critical point is reached, and the symmetry of the atom will be best preserved by adding electrons to another orbit. Critical points are reached with two, eight, or eighteen electrons in the orbit.

Perhaps a clearer notion of the operation of these laws may be obtained from a study of the diagram following. The orbit letters are given along the top line, the electron numbers at the left. The position of each atomic number on the body of the chart indicates the placement of the differentiating electron for that atom. Thus, for sodium, whose atomic number is 11, the differentiating electron is the first electron in the $M$ orbit. The law of capacity is illustrated in orbits $K$, $L$, $M$, and $N$, each of which is completely filled. The v-shaped solid lines indicate the law of symmetry. And the law of consistency may be observed by following the atomic numbers in numerical sequence.

There are three distinct levels on the chart. The distinguishing characteristic of these three levels is found in the placement of the differentiating electron. In the first, upper level, the electron difference occurs in the outer shell of electrons. In the second level, the electron difference occurs in the electron shell second from the outside. In the third level, the electron difference occurs in the electron shell third from the outside. Since the outer shell of electrons is the most effective one in determining the properties of an atom, with the inner shells progressively less effective, we would expect to find that there are great differences in the properties exhibited by elements in the first level, less difference on the second level, and least of all on the third level.

Our expectations are verified when we examine the properties of the elements which appear at each level. On the first level we find the representative elements, including metals, non-metals, inert elements, liquids,

THE PERIODIC TABLE

*The Representative Elements (Level 1)*

| *Electrons Orbits* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| K | $H_1$ | $He_2$ | | | | | | |
| L | $Li_3$ | $Be_4$ | $B_5$ | $C_6$ | $N_7$ | $O_8$ | $F_9$ | $Ne_{10}$ |
| M | $Na_{11}$ | $Mg_{12}$ | $Al_{13}$ | $Si_{14}$ | $P_{15}$ | $S_{16}$ | $Cl_{17}$ | $A_{18}$ |
| N | $K_{19}$ | $Ca_{20}$ | $Ga_{31}$ | $Ge_{32}$ | $As_{33}$ | $Se_{34}$ | $Br_{35}$ | $Kr_{36}$ |
| O | $Rb_{37}$ | $Sr_{38}$ | $In_{49}$ | $Sn_{50}$ | $Sb_{51}$ | $Te_{52}$ | $I_{53}$ | $Xe_{54}$ |
| P | $Cs_{55}$ | $Ba_{56}$ | $Ti_{81}$ | $Pb_{82}$ | $Bi_{83}$ | $Po_{84}$ | $Ab_{85}$ | $Ra_{86}$ |
| Q | $Vi_{87}$ | $Ra_{88}$ | | | | | | |

*The Related Metals (Level 2)*

| *Electrons Orbits* | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|
| M | $Sc_{21}$ | $Ti_{22}$ | $V_{23}$ | $Cr_{24}$ | $Mn_{25}$ | $Fe_{26}$ | $Co_{27}$ | $Ni_{28}$ | $Cu_{29}$ | $Zn_{30}$ |
| N | $Y_{39}$ | $Zr_{40}$ | $Cb_{41}$ | $Mo_{42}$ | $Ma_{43}$ | $Ru_{44}$ | $Rh_{45}$ | $Pd_{46}$ | $Ag_{47}$ | $Cd_{48}$ |
| O | $La_{57}$ | $Hf_{72}$ | $Ta_{73}$ | $W_{74}$ | $Re_{75}$ | $Os_{76}$ | $Ir_{77}$ | $Pt_{78}$ | $Au_{79}$ | $Hg_{80}$ |
| P | $Ac_{89}$ | $Th_{90}$ | $Ux_{91}$ | $U_{92}$ | | | | | | |

*The Rare Earths (Level 3)*

| *Electrons Orbits* | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Ce | Pr | Nd | Il | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |

and gases. On the next level we find the related metals, easily distinguishable from each other, but decidedly similar in their metallic properties and in the variety of valences they usually exhibit. On the lowest level we find the rare earth elements, whose resemblance to each other is so great that chemists have experienced much difficulty in separating and identifying them.

On the basis of these distinctions in atomic structure, the following periodic table has been constructed.

It is at once apparent that this arrangement eliminates the complications of long periods and rare earths mentioned earlier. The elements are logically grouped on the basis of their atomic structures. Through the use of this table, in conjunction with the preceding chart, it has been possible to develop rather effectively these two principles.

1. That the structures of the atoms are periodic functions of their atomic numbers.

2. That the properties of an atom are determined by its atomic structure.

Taken together these two statements are equivalent to, but more significant than, the usual statement of the periodic law.

## PROGRAM OF THE PHARMACY SECTION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Although a year has passed since the Elixir of Sulfanilamide incident with its tragic consequences, so far as we are aware there has been no attempt to get together all that is known about the glycols, despite the fact that perhaps no chemicals have been more widely discussed during this period than have certain members of this relatively simple family of compounds.

It has, therefore, occurred to those responsible for the program of the Pharmacy Section of the American Association for the Advancement of Science meeting to be held in Richmond during Christmas week, that a symposium on the glycols might be arranged that should prove highly informative and attract widespread interest. It is with genuine satisfaction that we are able to announce that plans have now been completed for such a symposium and, if carried through as provided for, will be almost definitive so far as knowledge of the better known glycols is concerned.

The subject will be discussed under four general heads, and the men who have accepted assignments for the symposium are acknowledged leaders in their respective fields. Dr. Frank C. Whitmore, President of the American Chemical Society, will discuss the chemistry of the glycols. Dr. H. O. Calvary, Chief Pharmacologist of the Food and Drug Administration, U. S. Department of Agriculture, will consider their physiological action. Mr. H. B. McClure, of the Carbide and Carbon Chemicals Corporation, will talk on their industrial uses; Dr. A. G. DuMez, Dean of the School of Pharmacy, University of Maryland, and Editor of Pharmaceutical Abstracts, will discuss their pharmaceutical uses.

After these formal papers are presented, a general discussion will be opened by Dr. H. B. Haag, Professor of Pharmacology at the Medical College of Virginia, and Dr. M. G. Milinos of Columbia University, College of Physicians and Surgeons. The program will be held on Tuesday, December 27, at 10:00 o'clock, in the salon of the Jefferson which is headquarters hotel.

The Program Committee is deeply indebted to Dr. Haag, himself a pharmacist, for much of the work involved in suggesting the subjects, and in choosing the men who will have the leading parts.

*Wortley F. Rudd*

## CLINICAL CHEMISTRY—A CORRECTION

As the result of an omission, no credit line was appended to the illustrations which appeared in this article [J. CHEM. EDUC., **15**, 511 (1938)]. Credit should have been given to the Fisher Scientific Company for the use of the cuts.

# CHEMISTRY *in the* SERVICE *of* AGRICULTURE*

H. A. HALVORSON

Minnesota State Department of Agriculture, Dairy and Food, St. Paul, Minnesota

AS CHEMISTS and chemical engineers, you will no doubt be interested in how the theories and principles of chemistry, which you have studied, can be made to serve industries related to agriculture. It would not be possible for one person, even if he had the time, to discuss more than a few of the methods by which chemists have applied their knowledge in the interest of producers, consumers, and processers of agricultural products. In this address, I intend first to speak in a general way only of several industries which depend to a great extent on laboratory results for the efficient conduct of business. Later I desire to show the relation of the chemist's work to investigational and regulatory problems of federal and state departments of agriculture, concluding with a more or less detailed discussion of the type of regulatory work with which I am most familiar.

For a great many years, this city has been a most important center of flour milling which is, properly speaking, a branch of the agricultural industry. In the early days, responsibility for selection of the wheat and the efficient reduction of it into flour rested solely on the miller. During the last twenty to twenty-five years, however, milling has become such a technical business that engineers and chemists are indispensable in any organization expecting to survive in the present competitive state of the business world. The chemist's skill and knowledge is applied in nearly all steps of the milling business, from the selection and blending of wheats to standardization of the finished products required by a sales organization. To fulfil his function, the chemist uses many of the same methods which some of you have already employed in your student work. To be sure the determinations are generally performed with greater skill and some modification of details, but the principles involved are no different. For example, the chief determinations in a flour mill or bakery laboratory are moisture, ash and protein in the wheat, flour, and offal, and baking tests conducted according to procedures given in such detail as all of you have found in descriptions of usual chemical methods. Of course, other procedures are sometimes employed, such as the determination of hydrogen-ion concentration and diastatic activity with which some of you may be familiar, since the former is merely a measure of acidity and the latter an estimation of the maltose content of flour.

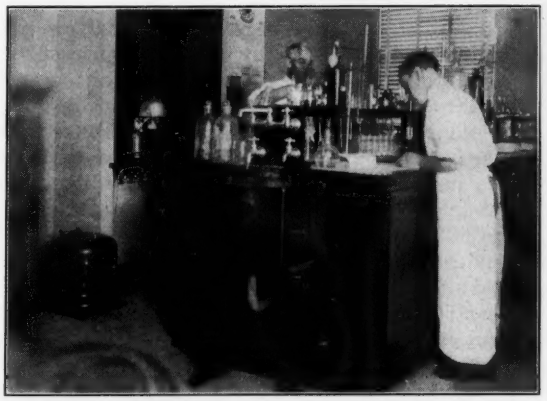
I have often thought that of all pursuits related to agriculture, the manufacture of fertilizers is the one that comes nearest to the classification of a chemical industry. This is probably true because these products early received the attention of experiment stations with a view to investigating their plant food constituents. This activity to find the elements responsible for improvement in crop production led to the passage of the first fertilizer law in Massachusetts in 1869. Soon after this, similar laws were passed in other eastern states, requiring manufacturers to label their brands with guarantees of the essential plant foods. The three elements for which guarantees are now required by practically all state fertilizer laws are nitrogen, phosphorus, and potassium, the two latter generally being expressed as the oxides. All important fertilizer manufacturers need extensive tests on materials purchased and finished mixtures bagged under their brands. As in the case of the milling industry, most chemical methods used in both industrial and state laboratories are those which many of you have learned. Routine work in these laboratories involves thousands of determinations of nitrogen; available, total, and insoluble phosphoric acid; also potash. For special purposes analyses are sometimes made for the nitrogen activity to determine the kind of materials used to supply this element to the mixture. At times qualitative or quantitative tests are made for the rarer constituents which are beginning to be regarded as detrimental or beneficial to crops or to animals consuming the crops. Chemists in the fertilizer industry have other problems to contend with besides those involved by their responsibility to see that products purchased and those leaving their plant meet the guarantees. Among these are studies of the effect of curing and storing on proper granulation, to prevent caking into hard lumps after sacking and to improve the flow of the fertilizers through the drills used by farmers in applying the materials to the soil. Analytical chemists are certainly an essential part of the fertilizer business, and the research engineer should also find plenty of problems in this industry to engage his ingenuity.

I wish to discuss now the feed manufacturing business, which is of more recent origin and lacks the historical background of the flour-milling and fertilizer industries. At first mixtures of grains and concentrates were blended on a more or less hit-or-miss basis, because persons entering that business had no scientific knowledge of animal nutrition. They merely

* Presented before a sectional meeting of the American Institute of Chemical Engineers, Minneapolis, April 13, 1937.

mixed together what was believed to be good feed. As time went on, however, results of experiment station investigations in animal feeding were distributed in bulletin form and reprinted in agricultural papers. Gradually, feeders demanded more and more information about the analysis and ingredients of these mixtures. Competition for business became keener so that manufacturers were compelled to employ chemists and feed experts to translate scientific data on nutrition to the compounding of their feeds. Thus we see that this business, which has been built up to immense proportions during the last quarter century, owes much to the findings of chemists and nutrition investigators.

In recent years feed manufacturers, especially in this country, have concocted rations for all types of animals and for nearly every conceivable purpose. For example, special diets are on the market for horses, cattle,

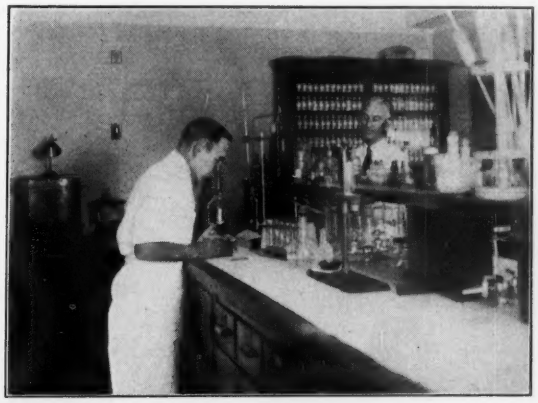


A SECTION OF LABORATORY ILLUSTRATING PART OF THE TECHNIC INVOLVED IN THE CALCIUM, PHOSPHORUS AND MAGNESIUM DETERMINATIONS IN CHICK BLOOD AND IN TEST RATIONS

dairy cows, sheep, pigs, poultry, dogs, cats, fur-bearing animals, rabbits, and other kinds of pets. Not only this but rations especially designed for the different periods of the animals' lives are obtainable. In the case of poultry only, we find such special diets as chick starting, growing, and brooder mashes, laying rations, fattening feeds, and others.

During the last thirty years, practically every state in the union has passed feed control laws for protection of farmers and other consumers. These laws are very much alike in their important provisions. All of them require, for example, minimum guarantees for protein and fat and maximum guarantees for crude fiber on mixtures and feed by-products of the milling, brewing, distilling, cottonseed, linseed oil, and other industries. In addition, manufacturers are compelled to enumerate the ingredients of feed mixtures. The analysis claimed and list of ingredients must be registered with a state department on proper forms and shown on labels attached to the bags in which rations are sold. Enforcement of these laws in the various states, direction of the compounding of feeds in the factories, and demonstration tests of rations by animal feeding experiments are the chemist's job.

It may be interesting now to see how these state laws are enforced, how feed chemists of the various states coöperate with each other, and how the Federal Food



A SECTION OF LABORATORY ILLUSTRATING PART OF THE TECHNIC INVOLVED IN THE CALCIUM, PHOSPHORUS AND MAGNESIUM DETERMINATIONS IN CHICK BLOOD AND IN TEST RATIONS

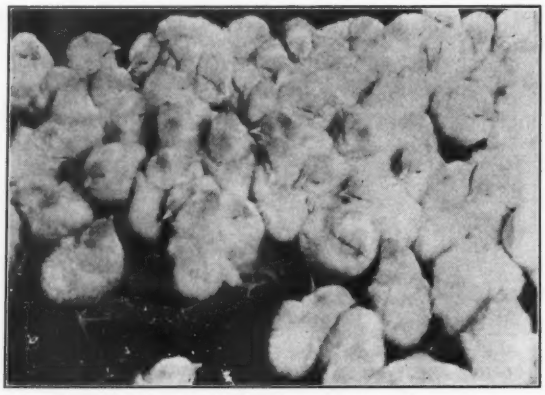
and Drugs Act supplements the operation of the state laws. A large percentage of the feed business is carried on in interstate commerce. Several feed manufacturers in Minneapolis, for instance, sell part of their output in states to the east of Minnesota. Nothing in the laws of the eastern states can prevent a Minnesota manufacturer from shipping illegal feed into those states. However, in doing so he would be very apt to violate the U. S. Food and Drugs Act, and his representative in the eastern state, who resold the feed, would be guilty of violation of that state's law.

Congress has never passed a special feedstuff law requiring registration of brands and labels with guarantees for nutrients. Provisions of the U. S. Food and Drugs Act, however, are so broad as to govern all types of animal feeds and remedies as well as drugs and human foods, but do not specify the labels to be used. Therefore, so far as the federal law is concerned, a manufacturer can ship unlabeled feed in interstate commerce, and it is only when he attempts to conform to the state laws which require statements of analysis and ingredients that the shipper is apt to run counter to the provisions of the Pure Food Law. If a false or inaccurate statement is made on the label of a product in interstate commerce, the federal authorities hold the shipper strictly accountable.

The Pure Food Law is enforced by a special bureau of the U. S. Department of Agriculture called "The Food and Drug Administration." This administration employs a large number of chemists, inspectors, clerks, and scientists engaged on special technical

problems. Branch laboratories of the bureau are located in principal cities, where samples from interstate shipments and those taken in the process of plant inspections are analyzed as part of the watch for violations of law. Through coöperative arrangements, information regarding goods contrary to national or local laws is exchanged by federal and state officials.

Further coöperation with special reference to feedstuffs is maintained between the state and federal de-



DAY-OLD WHITE LEGHORN CHICKS AT BEGINNING OF FEEDING PERIOD IN ASSAY OF POULTRY SUPPLEMENTS FOR VITAMIN D

partments through the Association of American Feed Control Officials. This group, consisting mostly of chemists, meets annually for the purpose of adopting official definitions and standards for all basic feed products. The chief object of the body is to maintain uniformity in laws, regulations, definitions, and standards for products of the feed industry. While decisions on definitions and other matters are made each year during a two-day session of the organization, special committees of its members are engaged throughout the year on investigations of the physical and chemical characteristics of new feed substances placed on the market, or on old products which may have been changed in composition by improvement or alterations in manufacturing processes. Proceedings of the association are published in annual pamphlets and frequently reprinted in part in feed bulletins of the various states.

Another group through which control chemists coöperate to solve their common problems is the Association of Official Agricultural Chemists. By virtue of their positions, federal and state chemists engaged in the analysis of, or chemical investigations on food, feed, drugs, fertilizers, leather, insecticides, and other agricultural products, are members of this association. The membership also includes experiment station soil chemists and others doing chemical work related to agriculture. Through investigations conducted by numerous referees assisted by collaborating chemists, methods are studied or devised with a view to their adoption as official procedures for the particular products considered. A journal is issued quarterly wherein referees' reports are printed in detail. The association also publishes a book of official and tentative methods containing over seven hundred pages, which is revised and brought up to date every five years. Hundreds of procedures for the analysis of every conceivable agricultural product are included in this book, and it is probably no exaggeration to say that millions of dollars have been expended in labor to make this book possible. No doubt, some of you have already used the A. O. A. C. Book of Methods in your laboratory work.

It may be interesting at this point to mention a few of the titles under which general and associate referee chemists of the association work. For example, there is a general referee on Soil and Liming Materials assisted by five associate referees studying such problems as the analysis of soil from arid and humid regions, liming materials, selenium, and less common metals of soils. A general referee and eleven chemists acting as associate referees are engaged in studying new and old methods for analysis of the various dairy products. Chemical problems relating to oils, fats, and waxes engage the attention of four referees. Metals in foods presents important problems requiring great analytical skill, and no less than eight chemists are acting as referees in this field of research. On fertilizers the general referee and several associate referees are studying specific problems in the analysis for phosphoric acid, notrogen, magnesium, manganese, potash, and the acid and base quality of these materials.

So far I have mentioned only a small proportion of the subjects under investigation at this time, and will conclude the list by merely referring to referee work concerned with the major part of this address. On feedingstuffs referees have been assigned the following subjects: fluorine, detection of adulteration by microscopy, mineral feed mixtures, lactose, hydrocyanic acid in glucoside-bearing materials, biological methods of vitamin D determinations, biological methods for vitamin B complexes, technic and details of biological methods, carotin, qualitative tests for proteins, fat in fish meal.

A few minutes ago, I referred to the U. S. Department of Agriculture and mentioned the division of that department which enforces the Food and Drugs Act. In your study of civics and history, you learned that the national government is a consolidation of states under a constitutional form. By the Constitution, certain powers were vested in the central government among which are the regulation of interstate commerce and levying of tariffs and duties. All authority not given the federal government was assumed to remain with the states. Therefore, while the states do not have power to impose duties on products of sister states, and cannot regulate foreign imports and goods in interstate commerce, they do have the right to police the sales of all materials sold within their own boundaries. Within certain limits of the Constitution, each commonwealth is similar to a sovereign state with

full right to govern itself as it sees best. To protect its citizens against adulteration and misbranding of food and feed products and to prevent the sale of substances injurious to human beings and animals, each state has its own code of laws, generally enforced by a state department of agriculture similar in many respects to each other and to the federal department.

In our own state, the Minnesota Department of Agriculture, Dairy and Food has been charged with the responsibility of regulating the processing and sale of many agricultural products, the prosecution of false advertisers, and the fostering of all activities tending to promote the well-being of agriculture and related pursuits. In all its activity, the Department employs about two hundred people. A few of its duties are the promotion of coöperative enterprises; the licensing of wholesale dealers in agricultural products; the grading of fruits and vegetables at central markets to protect the producer against unfair practices; the regulation of dealers in milk and cream; and licensing persons performing the Babcock test on which milk and cream are purchased; the irradication of weeds; the inspection and analysis of seeds, feeds, fertilizers, foods, and beverages; the inspection for sanitary and technical improvement of processes in creameries, canneries, cheese factories, and ice cream plants; also, the sanitary inspection of dairies and milk distributors.

As a matter of convenience or efficiency, certain types of the work just listed are properly grouped together and the duties performed under direction of a division head. Separate laboratories are maintained where foods, canned goods, and oils are analyzed or graded and where bacteriological work is done. Personally, my interest centers in the inspection and analysis of feeds and fertilizers. For that purpose, we have a staff of clerks, inspectors, and chemists with all necessary apparatus, including a well-equipped laboratory.

With your permission I will briefly describe the methods employed for collection, examination, and reporting of results on feeds and fertilizers. Any person who desires to sell mixed or by-product feeds in Minnesota must file a registration for each brand enumerating: net weight of package, name of product, name and address of manufacturer, and the guaranteed analysis; and on mixtures he must also name the ingredients. A label giving the same information must be attached to every bag sold in the state, so the purchaser may know the feeding value in terms of protein, fat and fiber, and the materials which have been used. A similar procedure is required for every brand of fertilizer placed on Minnesota markets.

To be sure that the law is obeyed, inspectors visit every town in the state and secure samples of materials, which have not previously been tested too often. Laboratory examination shows how well each product meets the guarantees in registration and label. Besides microscopic examination to identify ingredients claimed and quantitative tests for protein, fat and fiber; determinations of moisture, ash, calcium, phosphorus, magnesium, salt, and iodine are made as occasions require. These extra tests frequently give purchasers information essential to the intelligent feeding of their stock.

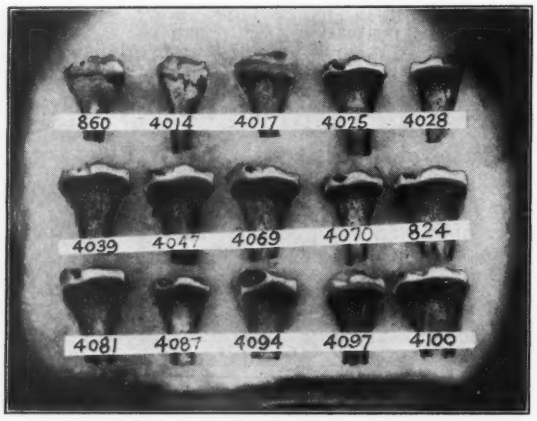
The results of all tests as soon as completed are sent to the party responsible for the product being on the market. Copies of reports are sent to dealers from whom the samples were obtained, and are available for public distribution. At the end of each year all data are published in the Annual Feed and Fertilizer Bulletins. These bulletins are distributed to manufacturers, dealers, farmers, agricultural schools, libraries, and other places. Generally manufacturers take a great pride in their brands and are anxious to so blend and label their feeds as to avoid criticisms in the bulletins. Of course, the enforcing department has the option of prosecuting in court violations where it is apparent that publication of adverse findings will not remedy the situation.

I desire now to discuss rather fully a comparatively new phase of feed inspection work. You may have noticed that recently newspapers, magazines, and feed trade journals have contained many advertisements and items regarding the vitamin value of various products. About ten years ago mixers began to incorporate one or more of these advertised supplements in their feeds. Statements made regarding the vitamin-containing substances often influenced manufacturers to claim their poultry mashes contained vitamin D, and from these claims purchasers were lead to believe that these feeds were superior to others for improving growth, hatchability, or egg production. Farmers, hatcherymen, and poultry feeders too frequently failed to secure the expected results, and in consequence sought the reasons from the state experiment station or complained to the feed control laboratories. Control chemists were not then equipped to give expert advice on these matters, but, as time went on, the feed officials recognized that this problem demanded serious attention. Like the chemists in the other states, we at Minnesota expected that methods could be devised to determine the vitamin D potency of mixed feeds, if only investigators could devote the necessary time to their solution. None of us, then, realized the work which would be involved, but several state chemists, notably of Wisconsin, Minnesota, and Maryland, decided to make the beginning required. Since vitamin D was known to be most deficient in ordinary rations, we decided to begin tests for this factor in the supplements used in feeds.

As you know, cod-liver oil has for many years been the principal source of vitamin D. In fact, it was used as an antirachitic hundreds of years before scientists knew that vitamin D existed. According to a historical review by Dr. Ruth Guy, cod-liver oil was employed in ancient times by the fishermen along the northern coasts of Europe for invalids and people in poor health, and also was greatly relished as a substitute for butter. The first reported use of cod-liver oil by the medical profession was as an external remedy at the Manchester Infirmary in England about 1789.

While no known person can be said actually to have discovered that cod-liver oil was a preventive of rickets in this country, Dr. E. V. McCollum and co-workers in 1922 demonstrated the existence of a fat-soluble vitamin in cod-liver oil, which was distinct from vitamin A and which is now known to be vitamin D.

Prior to 1925, practically none of the poultry feed sold in Minnesota contained vitamin D carriers as ingredients. Since that year, the number of brands containing cod-liver oil or other sources of vitamin D has increased rapidly, until now it is very seldom that any one markets a mash without such added supplements. Over ninety per cent. of the seven hundred twenty-seven new registrations for starting, growing, and egg mashes filed here in 1936 contain added vitamin D carriers, generally cod-liver oil or sardine oil.




PHOTOGRAPHS ARE OF SILVER NITRATE STAINED SECTIONS OF TIBIAE FROM EIGHT-WEEK OLD CHICKS. CONTRAST DEFINITE LINE OF CALCIFICATION IN BIRD NUMBER 4039 (BONE ASH 50.4 PER CENT.) WITH INDEFINITE APPEARANCE OF LINE IN TIBIA NUMBER 860 (BONE ASH 38.3 PER CENT.). BIRD NUMBER 860 RECEIVED NO VITAMIN D. BIRD NUMBER 4039 RECEIVED VITAMIN D IN FORM OF COD-LIVER OIL.

| *Bird No.* | *Sex* | *Age Weeks* | *Weight Grams* | *Bone Ash Per Cent.* | *Diagnosis* |
|---|---|---|---|---|---|
| 860 | ♂ | 8 | 298 (average) | 38.34 | Definite rachitic lesions |
| 4014 | ♀ | 8 | 228 (light) | 37.95 | |
| 4017 | ♂ | 8 | 450 (heavy) | 35.19 | |
| 4025 | ♀ | 8 | 634 (average) | 52.52 | Normal |
| 4028 | ♀ | 8 | 524 (light) | 50.91 | Normal |
| 4039 | ♂ | 8 | 804 (heavy) | 50.39 | Normal |
| 4047 | ♂ | 8 | 812 (heavy) | 50.19 | Normal |
| 4069 | ♂ | 8 | 656 (average) | 46.65 | Normal |
| 4070 | ♀ | 8 | 510 (light) | 48.70 | Normal |
| 824 | ♂ | 8 | 820 (heavy) | 47.42 | Normal |
| 4081 | ♂ | 8 | 686 (average) | 49.36 | Normal |
| 4087 | ♀ | 8 | 560 (light) | 48.67 | Normal |
| 4094 | ♀ | 8 | 658 (average) | 49.18 | Normal |
| 4097 | ♀ | 8 | 510 (light) | 45.57 | Deviates slightly from normal |
| 4100 | ♂ | 8 | 896 (heavy) | 50.09 | Normal |

The best known source of vitamin D are fish liver or fish body oils; cod-liver oil being representative of the former and sardine oil of the latter. Other oils rich in vitamin D are liver oils of the burbot, tuna, goose fish, and shark, and body oils of the sardine, herring, salmon, tuna, and menhaden. The potency is influenced greatly by the fishing season, process of manufacture and care in refining, and these factors may account for the fact that cod-liver oils on Minnesota markets have varied as much as eight hundred per cent. in antirachitic value.

The antirachitic factor resides in the unsaponifiable material of oils. To separate this part from the saponifiable portion, several processes have been devised and patented, thereby producing a concentrate very rich in vitamin D. This vitamin D concentrate is sometimes added to ordinary cod-liver oil to standardize it, or to greatly increase its potency so that the mixed product may be marketed as a concentrated or fortified cod-liver oil.

Direct sunlight has been repeatedly stated to be the cheapest and best source of vitamin D, but clouds, haze, and the small angle of incidence with the horizon of the sun's rays (as in winter months) diminish its effect, since much of the ultra-violet rays are filtered under these conditions and by glass, shade, and other substances through which light must pass before reaching the animal body. Poultry feeders are depending more and more upon an added supplement to the feed to supply the required vitamin D. At first, the supplements were used in rations only at certain periods of the chicken's life, *i. e.*, for a few months after hatching and during the winter laying season. There is a distinct trend now (and a number of poultry specialists recommend it) to incorporate one to two per cent. of ordinary cod-liver oil, or its equivalent, in starting, growing, breeding, and laying mashes during the entire year.

The tremendous amount of cod-liver oil and other supplements required to satisfy the present demand for vitamin D in chicken mashes measures the importance of developing methods which will fairly and accurately show the effect of these supplements on poultry. In 1930 when we undertook the task of making these tests, practically all investigations with vitamin D assay methods were made with white rats. Up to this time and at present little or no progress has been made to develop suitable chemical methods of testing for vitamin D. Since the rat assay methods were previously used almost exclusively in research laboratories, data regarding units of value are generally expressed in terms of these tests. Recently, the chick assay has received considerable study, not only by the state control departments, but also by several university and commercial laboratories.

We have, then, two distinct biological methods of assay: (1) the rat assay—a curative test, also called the "line test," and (2) the chick assay method. In the line test the rats are fed a vitamin D deficient ration for a definite number of days to induce rickets in the animals. After this, vitamin D in the form of cod-liver oil or other substance to be tested is administered to the rats for a definite period. The curative effect of the administration of the vitamin D based upon the quantities fed is measured by the line test,

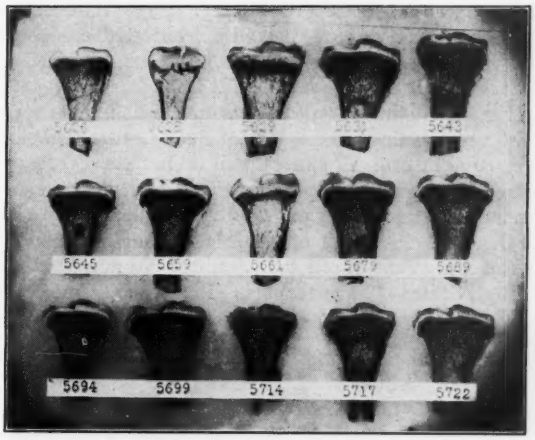
which is an observation of the amount of calcium salts deposited in the bones.

For the purpose of discussion I have arbitrarily subdivided the chick assay method into three technics, any one or all of which may be used by a laboratory to determine the effect of the administration of vitamin D. The chick assay method which has been tentatively adopted by the Association of Official Agricultural Chemists is called a preventive biological test. In the state laboratories the effect of the vitamin D is measured by the determination of the bone ash in the tibiae of the chicks. Several commercial laboratories employ a second technic by which the degree of rickets or the prevention of this disease is determined from photographs of the internal structure (stained with silver nitrate) of the tibiae. The third technic involves diagnosis of calcification in the bones of the chicks by photographic pictures of X-ray exposure of the bones.

Of course, all chick feeding tests for vitamin D do not specify the same ration as that given in the A. O. A. C. method. The composition of the A. O. A. C. basal ration is stated in the Journal of the A. O. A. C. (Volume 17, page 69) and in publications of the Minnesota Department of Agriculture. The three state laboratories, which have been mentioned as actually doing control work on vitamin D, use the tentative A. O. A C method.

Our first problem in the development of the A. O. A. C. method was to find a suitable ration for the chicks. Such a ration must be one which is devoid or nearly devoid of vitamin D, but which otherwise contains all the recognized nutritional factors, including the proper percentage and balance of the mineral elements, satisfactory quality and content of protein, and the vitamins with the exception of D, which are known to be necessary in successful poultry feeding. A good basal ration then must be one which will produce good growth when supplemented with vitamin D, permit a majority of the birds to live to the end of the experiment, and at the same time induce severe rickets in the chicks before the end of the feeding period.

When the basal A. O. A. C. ration is fed to a group of baby chicks for four or five weeks, they will live for that period, but will be subnormal in weight and exhibit all the symptoms of rickets. At four weeks of age, the birds are generally so weak as to be hardly able to take nourishment. The feathers are ruffled. They walk with a stilted gait or show a marked tendency to squat and extreme leg weakness. At the conclusion of the feeding period, which has been recently shortened to three weeks, the chicks are all killed, the left tibia removed, and after proper treatment the bone ash determined. The average bone ash content of the tibiae in these negative control groups approximates thirty per cent. When tests are made of samples collected from stocks on the market, definite quantities of supplement (ranging in the case of cod-liver oils from 0.25 per cent. to one per cent.) are added to the basal ration which is then fed to groups of chicks similar to the negative controls. If the amount of supplement added has fully protected the birds, the bone ash contents of the tibiae will average about forty-five per cent. at four weeks of age. Thus, we have a range of about fifteen per cent. in average bone ash content between rachitic chicks from the negative control groups and normal ones in groups which have received adequate supplies of vitamin D. According to a resolution of the Association of American Feed Control Officials, adopted as a regulation in Minnesota, every distributor of a vitamin D supplement must register his product with the state, and label it with a guarantee of antirachitic potency




PHOTOGRAPHS ARE OF SILVER NITRATE STAINED SECTIONS OF TIBIAE FROM EIGHT-WEEK-OLD CHICKS. NOTE INDEFINITE LINE AT THE TOP OF TIBIA NUMBER 5629 (BONE ASH 39.31 PER CENT.) COMPARED WITH THE DEFINITE LINE OF CALCIFICATION AT THE TOP OF TIBIA NUMBER 5631 (BONE ASH 50.57 PER CENT.). NUMBER 5629 RECEIVED NO VITAMIN D. NUMBER 5631 RECEIVED VITAMIN D IN THE FORM OF COD-LIVER OIL

showing the minimum number of A. O. A. C. chick units of vitamin D per gram. The guarantees made in registrations and the results of our tests are published in several annual reports.

The units which have been used in the past have varied in value depending upon the names applied to them, although several units with different names have been of equal value. On page 5 of our 1934 report of vitamin D tests, we have presented a table of rat unit equivalents, so that one can conveniently determine the value of any one of seven units in terms of the other six. To illustrate, the table shows that 1 D unit is equal to 36 International units, 36 U.S.P. units, 13.33 Steenbock units, 13.33 American Medical Association units, 133.30 American Drug Manufacturers Association units, or 60 Oslo units.

To further confuse the layman who desired to know the relative value for poultry of the different products offered to him, it is astonishingly true that one rat unit (be it International, Oslo, or any other designation) is not necessarily of the same efficacy for poultry when derived from different substances. For example—one

International vitamin D rat unit in cod-liver oil may have the same value for preventing rickets in chickens that fifty similar units may have in the form of irradiated yeast or irradiated ergosterol. Recent investigational work points to the existence of at least two forms of vitamin D. Not long ago, Bills and associates published a paper suggesting this, and stated that the vitamin D in blue fin tuna liver oil is a different substance or a different mixture of substances than the vitamin D in cod-liver oil. For chicken use they found that one rat unit of the antirachitic factor in blue fin tuna liver oil is only about fifteen per cent. as effective as that in cod-liver oil. A very important paper by Dr. Waddell, of the Acetol Products Company, shows that irradiated cholesterol in contrast with irradiated ergosterol is as effective (for poultry), rat unit for rat unit, as the vitamin D in cod-liver oil.

It is hoped that recent adoption of a definition for a chick unit by the Associations of Feed Control Officials and Agricultural Chemists will eliminate confusion caused by a multiplicity of units of questionable value for use in guarantees on poultry supplements. One A. O. A. C. chick unit of vitamin D is defined now to be the equivalent of one U.S.P. unit of vitamin D in the United States Pharmacopoeia Reference Cod-Liver Oil. The revision of the A. O. A. C. method to authorize comparative tests of commercial products with the Reference Cod-Liver Oil will also help greatly to standardize all antirachitics on the market.

Investigational work undertaken at Minnesota has always been planned for the principal purpose of shortening, improving, or extending the scope of the A. O. A. C. method for the estimation of vitamin D in feedingstuffs. Criticisms have, of course, been directed against this procedure by firms whose products have been regulated and to a lesser extent by others. The feeding period used by commercial firms to show growth and improvement in bone structure, as a result of feeding rations supplemented with their products, was generally eight weeks or longer. The state laboratories' first proposal was for a six-week feeding period, which was soon shortened to five weeks. This was objected to by firms using a longer feeding time. A statistical investigation made in our own laboratory answered these arguments and demonstrated that four weeks of feeding in the A. O. A. C. method were as satisfactory as the five-week period. More recent work has shown little loss of accuracy in reducing the feeding time to three weeks, a self-evident improvement in this type of work.

# SHOULD QUANTITATIVE ANALYSIS BE TAUGHT *before* QUALITATIVE ANALYSIS?

LYLE O. HILL AND WILLIAM F. CRAMER

Central Y. M. C. A. College, Chicago, Illinois

PROBABLY the most difficult task in the teaching of college chemistry is the coördination of the laboratory work and the theoretical material which is covered in the course in qualitative analysis. Practically all teachers admit that this is desirable and strive for this coördination; however, very few have been satisfied with their results. The laboratory work in the first part of the course is mainly cookbook in style. Usually the end of the course is reached before the student begins to see the relation between the laboratory work and the material discussed in the lecture room. Several times we have tried rearranging the material which is most essential for the qualitative course in such a way as to make a better coördination between the laboratory work and the lecture material. Our results have not been all that could be desired, however. When we follow the logical order for an ultimate analysis, are we following the most effective method of presenting this fundamental material to our students? Or should we reverse our present order and make introductory quantitative analysis a prerequisite for qualitative analysis? Since the chemistry involved in the analysis of the unknowns usually used in the first quantitative course is so much simpler than that encountered in the qualitative scheme the authors believe that this rearrangement will be preferable in obtaining the objectives of these courses.

Before proceeding further, we might outline the more important objectives of a qualitative and a quantitative course.

(1) Create scientific interest. The application of quantitative work to nearly all types of commercial work, as well as all phases of chemistry, is easily pointed out by the instructor. This gives the students a feeling that they are doing chemical work rather than preparing to do it.

(2) A working knowledge of solutions of electrolytes.

(3) The development of manipulative skill in the laboratory.

(4) An appreciation of the application of theories and laws to the practical laboratory work.

The long delay in bringing out the fourth objective in the course in qualitative analysis is the problem with which we are confronted.

If quantitative analysis were taught before qualitative analysis the student entering the qualitative course would have sufficient background to avoid the delay in coördinating the laboratory work and the theoretical material. Would there be a similar delay in the quantitative course? By use of the following order it is believed that no such delay would occur.

(1) An introductory discussion of the use of the quantitative apparatus.

(2) A discussion of stoichiometry of acids and bases which brings out the practical application of the atomic theory. There is no logical place to bring in this discussion in the qualitative course, although it is needed before the introduction of the mass law, since most students do not get a sufficient background in their general chemistry.

(3) The application of the mass law and hydrolysis to acidimetry and alkalimetry. The titration of acetic acid. The choice of an indicator in the titration of a weak electrolyte shows the practical application of the mass law in a much more simple and more fundamental manner than is shown at any place in the qualitative scheme.

(4) The stoichiometry of oxidation-reduction reaction shows much more forcibly the need for the ability to balance oxidation-reduction equations than any reason that can be given in connection with the qualitative scheme. Also, the reactions involved in the determination of iron or copper are much more simple than those reactions encountered with the copper-arsenic group of the hydrogen sulfide scheme.

(5) The application of the solubility product law to gravimetric work brings out a number of very interesting practical examples such as the amount of precipitate that will dissolve in the wash solution and the effect of the common ion in loss of the precipitate due to solution.

(6) Coprecipitation. A little knowledge of this phenomenon should be an asset when discussing the qualitative scheme. However, it is usually not considered until the quantitative course.

If the student entering qualitative analysis has studied the material outlined above, only a short time would be required to study the application of the mass law to complex ions and to discuss amphoteric compounds. Then a student would be ready for a complete breakdown and study of the qualitative scheme, based on the above theories and laws, which could proceed along with the work in the laboratory.

Two of the objections to this suggested order are:

(1) The logical order of an analysis is a qualitative analysis and then a quantitative analysis, which is probably the reason for the order now in use. Chemistry, however, has developed so that it is very seldom necessary for a chemist to run a qualitative analysis.

(2) The technic acquired in the qualitative laboratory work aids the quantitative work. This is no doubt true, but is it necessary? Would not the technic acquired in quantitative be more valuable in doing qualitative work?

There are a few administrative problems that will arise with this order. More time will have to be scheduled for the lecture work in the quantitative course, and, therefore, less laboratory work required, or the credit hours increased. Would the quantitative course as outlined meet the entrance requirements of certain professional schools, particularly pharmacy where only one analytical course is expected?

At the present time we are considering the adoption of this plan in either the spring or the fall of 1939 at the Central Y. M. C. A. College. Before we make such a move, however, we would like to have the opinions and suggestions of others interested in teaching these two courses.

Needless to say, we expect to keep complete records so that the progress of students taking quantitative analysis first can be compared with that of students taking qualitative analysis first. We have at our disposal rather complete records on each of our students. Using these we shall study our results by the method of equated groups. Criteria for matching the experimental and control groups will be (1) general ability as determined by a psychological examination; (2) general scholarship as measured by college marks; and (3) marks in general chemistry.

# SALTWORKS *of* NEW JERSEY *during the* AMERICAN REVOLUTION

K. BRADDOCK-ROGERS

Haddonfield, New Jersey

COLONIAL New Jersey had no major dependable salt supply, and it was forced to rely on material imported from sister colonies and other external sources. Massachusetts, on the contrary, because of her fisheries had a long-established salt industry. To the south several small saltworks were to be found in Virginia. During the American Revolution the British naval blockade and the isolation by the army of the Middle Atlantic Colonies from New England and the South cut off the salt supply of New Jersey. Salt was needed, and the wartime saltworks along the Jersey coast was the result.

The demand for salt was felt almost immediately after the war began. Realizing this present and growing need of the people for salt, the Continental Congress passed a series of resolutions which reflect the general situation very well. The first was passed on December 29, 1775, and "earnestly recommended to the several Assemblies and Conventions to promote by sufficient public encouragement the making of salt in their respective Colonies." Eighteen months later (June, 1777) it was resolved "that a Committee of Three be appointed to devise ways and means of supplying the United States with Salt." On Friday, ten days later, the report of this Committee was

> Resolved.—That it be recommended to the several States to offer such liberal encouragement to persons importing salt for the use of the said States as they judge will be effectual; . . . . . That it be recommended to each State to employ one or more vessels for the importation of salt into their respective States; . . . . . That it be recommended to the several States to erect and encourage in the most liberal and effectual manner proper works for the making of salt.

Four years later Congress reiterated their first resolution and in the following November "recommended that the article of salt be left unlimited in price which is of indispensable necessity to all ranks of the people and often difficult to procure."[1]

New Jersey passed an act in October, 1776 ". . . . . to encourage several men to erect saltworks." The outcome of this venture is unknown. One year later an act was passed ". . . . . for erecting Saltworks and manufacturing Salt within the State of New Jersey." By this act Commissioners were appointed to buy land on the coast, erect buildings, and purchase the necessary materials and implements for saltmaking. But ". . . . . business being unexpectedly delayed and a great number of Private Works erected the design was dropped." The act was repealed in March, 1778.[2]

Pennsylvania in the Spring of 1776 appointed a Committee on Saltworks which made its report in June.

> The Committee appointed to consider the most certain and effectual methods of supplying the Inhabitants of this Colony with Salt, Report, that they have examined the plan proposed by Thomas Savadge for making annually on the Sea Coast about sixty thousand bushels and are of the opinion the necessary works may be completed in a short time at an expense not exceeding two thousand pounds, but as the Committee conceive this quantity not altogether equal to the consumption of the Colony they earnestly recommend to the House an undertaking of greater extent to be under the direction of Persons of such activity and zeal as may give a reasonable hope that the public necessities in this article may be fully relieved without depending on a precarious supply from abroad, which can only be obtained at an exorbitant rate.

The construction of saltworks by the State of Pennsylvania was started immediately. In August the Council of Safety appointed a Committee to carry on the saltworks under the direct management of Thomas Savadge. These works were located at the mouth of Goose Creek a few miles from Tom's River, New Jersey.

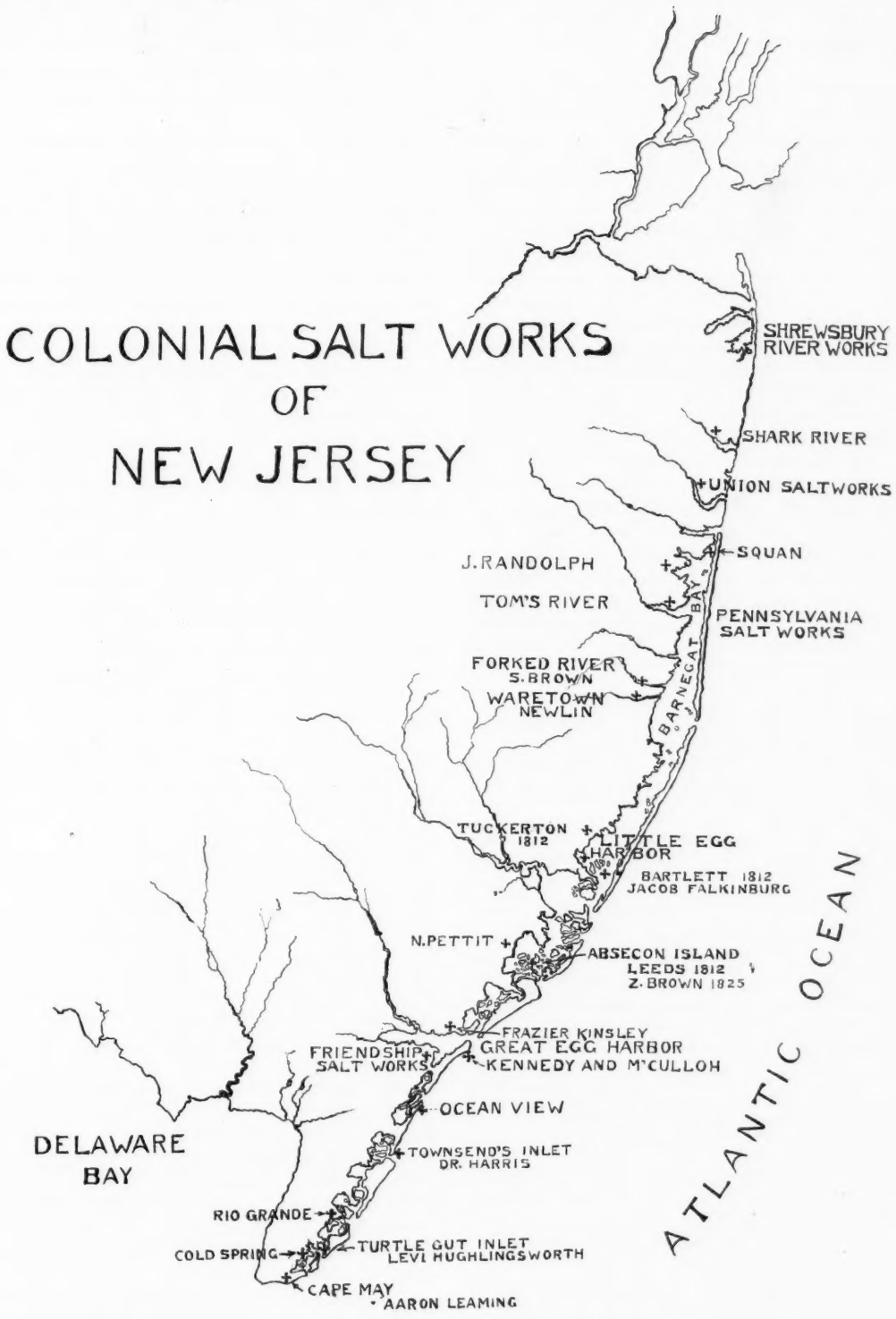
Other saltworks rapidly made their appearance until eighteen or twenty dotted the coast. Thus through the necessities of the times came into being these Colonial Saltworks of New Jersey.

THE SALTWORKS DURING THE REVOLUTION

Union Saltworks near the Manasquan River.
A small Works at the mouth of the Shrewsbury River.
Sharp River, Squan, and Barnegat Bay. Several Works at each place.
James Randolph's Works at Mosquito Cove.
Pennsylvania Saltworks at Goose Creek.
—Newlin, Waretown.
Samuel Brown, Forked River.
Friendship Saltworks, Thomas Hopkins, Manager, Great Egg Harbor.
Thomas Heston and Co., Falkinburg Island, Little Egg Harbor. These works were probably taken over by Jacob Falkinburg.
Nathaniel Pettit, two miles North of Absequan River and eighteen miles South of the Forks of the Little Egg Harbor.
Frazier Kinsley, Great Egg Harbor.
Kennedy and McCulloh, three miles from Great Egg Harbor Bar.
Dr. Robert Harris, Townsend's Inlet.
Levi Hughlingsworth, Turtle Gut Inlet.
Aaron Leaming, Cape May.
Ocean View, Rio Grande, and Cold Spring. Several works at each place.

[1] Journals of the Continental Congress," Washington, 1908, Vols. 8, 14, 15.

[2] "The Acts of New Jersey," 1775–1782.


COLONIAL SALT WORKS
OF
NEW JERSEY
SHREWSBURY
RIVER WORKS
SHARK RIVER
UNION SALTWORKS
SQUAN
J. RANDOLPH
TOM'S RIVER
PENNSYLVANIA
SALT WORKS
FORKED RIVER
S. BROWN
WARETOWN
NEWLIN
BARNEGAT BAY
TUCKERTON
1812
LITTLE EGG
HARBOR
BARTLETT 1812
JACOB FALKINBURG
N. PETTIT
ABSECON ISLAND
LEEDS 1812
Z. BROWN 1825
FRAZIER KINSLEY
FRIENDSHIP
SALT WORKS
GREAT EGG HARBOR
KENNEDY AND M'CULLOH
OCEAN VIEW
DELAWARE
BAY
TOWNSEND'S INLET
DR. HARRIS
RIO GRANDE
COLD SPRING
TURTLE GUT INLET
LEVI HUGHLINGSWORTH
CAPE MAY
AARON LEAMING
ATLANTIC OCEAN

THE SALTWORKS AFTER THE REVOLUTION*

Leeds, Absecon Island near Atlantic City.
Bartlett, near Little Egg Harbor.
Zadock Brown, Absecon Island.
Thacher, Tuckerton.

The saltworks of which we have the most information are the Pennsylvania Saltworks, the Friendship Saltworks, the Union Saltworks, and the works of Aaron Leaming at Cape May. Quite a complete record of the first is reflected in the voluminous correspondence between the Council of Safety and Thomas Savadge, and in the Waste Book of the Pennsylvania Saltworks.† The Waste Book gives a complete and uninterrupted business record of the works. The first entry is June 26, 1776, in which are orders for lumber, tools, brick from Egg Harbor, traveling expenses, a raft, etc., etc. Over a period of months large sums are paid to James Collins and Co. for hauling brick and iron plates from Egg Harbor. There are large sums due John Cox and Lawrence Saltar and Co.‡

There are also traveling expenses to and from Egg Harbor, Batsto, Atsion, Philadelphia, and other important points. There is an order to one Jeremiah Baker, for fifty salt baskets and there are regular entries to men for wages for all manner of work. The wages to Savadge are far from forgotten.

From the many letters and reports we see that the construction and administration of these works was not plain sailing. The magnitude of the undertaking is well set forth in one of the first reports of Savadge to the Council in which he states,

"I have nearly completed a boiling house one hundred sixty-nine feet long, twenty-nine feet wide; a store sixty feet long, twenty feet wide; completed two drying houses, a small kitchen, a lime house, stable finished, mill work for my pumps in good forwardness, will be completed before I shall get my boilers from Colonel Cox's Furnace whose people have disappointed me or should have had part of the works completed before this. Also a large quantity of stuff joynted and ready for flooring the sun pans etc.,. . . with many other things such as laying trunks, ditches, etc.". . .

The manager was beset with many difficulties; labor troubles, financial worries, incursions of the enemy, to say nothing of his own querulous, pessimistic, and complaining nature. The Council of Safety met him at every turn in an endeavor to promote the work. Money was generously sent at every request to be used as he saw fit. To the advice that the works needed military protection it was ordered in November, 1776, "that an officer and twenty-five men be sent to the saltworks . . . as a guard" and in the following February "that in consequence of the advice from Thomas Savadge . . . the armed boat 'Delaware' under the command of Captain Richard Eyre be immediately fitted out and ordered to proceed with all expedition to the said works." These are two of many examples of the willingness of the Council to send boats and men for the protection of these works in which so much faith was placed.

The majority of the men who were employed at the works lived in the neighborhood and were subject to call for duty in the militia. This fact was made known to Governor Livingston of New Jersey and at his recommendation the Legislature very shortly passed a law which gave exemption from militia service "to one man at each saltworks for every five hundred gallons the boiling vessels held." Not content with the generous fulfilment of his many requests Savadge kept asking for supplies of all kinds; rum, stoves, more blankets, building materials, ironwork, and more land for wood. The answer to the last was a purchase of fourteen hundred acres of woodland.

It will be recalled that the construction of the works was underway in June, 1776. Late in October Savadge reported "that millwork for my pumps in good forwardness," yet in July, 1777, Savadge wrote ". . . I have about two weeks work to do at the mill and pumps which would enable me to get four pans at work and the remainder in a short time" and a month later he wrote ". . . my millwrights have nearly completed the mill and the pumpwork, when done shall get to work with two or three pans in a few days." With such repeated delays it is no wonder that overtures were made by Pennsylvania to operators of other works. Levi Hughlingsworth of Turtle Gut Inlet made an offer to sell his works to the State, but nothing came of it. There were also negotiations between the State and Dr. Harris, of whom more will be said.

The saltworks at Tom's River were a great disappointment to the Council. They wrote to Colonel Cox at Batsto in November, 1777, "disappointed and fatigued with Mr. Savadge's delays we have at length employed the bearer, Mr. Davidson, to visit the works and furnish us if possible with a distinct account of matters there. . ." Davidson was ordered to report in full on the works and to buy salt from other works. In January Savadge reported that two pans were complete and that he had about twenty bushels of salt on hand. This seemed to have heartened the Council and it resolved ". . . to push the works vigorously." At the same time Davidson was ordered to take over the management of the works; an order which Savadge deeply resented. This was the beginning of the end of the Pennsylvania Saltworks, which it was estimated by Savadge would ". . . give a yield of salt proportionable to 300,000 bushels per annum." In the Waste Book under May, 1778, is the credit of twenty bushels of salt, the first in almost two years of operation and thereafter there are a few such items. The saltworks continued to operate with little or no results until they shut down in 1779. The last entry in the Waste Book is April 10, 1779. Sometime in September, Savadge

* The report in certain local histories that the Continental Congress operated saltworks on the Jersey coast is without foundation.

† The Waste Book of the Pennsylvania Saltworks is in possession of the Pennsylvania Historical Society, Philadelphia.

‡ John Cox was owner and operator of the great Batsto Furnace in New Jersey, and Saltar was the owner and operator of the Atsion Furnace which was a few miles from Batsto. For an account of these furnaces and others see BRADDOCK-ROGERS, K., "Bog ore industry in South Jersey prior to 1845," J. CHEM. EDUC., 7, 1493 (1930).

died and the works were put in charge of Colonel Hagner to dispose of them by public sale or by any means he saw fit. Accordingly, the following advertisement appeared in the Pennsylvania Packet, November 9, 1779.

THE STATE SALTWORKS TO BE SOLD

On Monday the fifteenth day of November inst. will be sold by Public Vendue the Saltworks belonging to the State of Pennsylvania . . . . .These works have been erected on a very extensive plan calculated to make a quantity of Salt and in a situation most favorable for the purpose. The Buildings are large, commodious and in good order, consisting of a dwelling house, boiling house, drying house, two store houses, a windmill for raising the salt water by pumps and a smith's shop etc., etc. . . . .

FREDERICK HAGNER

On December 31, 1779, the deed was signed for the transfer of the Pennsylvania Saltworks to John Thompson of Burlington County for fifteen thousand pounds. Nothing more is known of these ill-fated works until a few years ago when the site was sold for a summer colony. When workmen were digging to drain and fill in a section of marsh land, they uncovered a stone wall two hundred fifty feet long with three sets of sluices and gates. This was the dam for the saltworks pond. These last remains of a great project were totally destroyed.*

Allusion has been made to the Friendship Saltworks which were on Great Egg Harbor. Like all the others it is not known when it started nor how long it operated. Thomas Hopkins, Quaker, was the manager of the works. A portion of his Journal remains and in it he gives a faithful and humorous account of the works. He refers several times to the owners but omits their names.†

He notes in his Journal the daily output of salt, but unfortunately it is in units which are meaningless. A description of these works from an advertisement is as follows.

On Tuesday the 20th instant, will be sold at Public Vendue, The Friendship Saltworks, situate on Great Egg Harbor, two miles to the eastward of Absecon Bridge, to-gether with all the buildings, improvement and implements necessary for carrying on the business. The works consist of 8 wrought iron pans, all lately set up on a new construction far superior to any other on the continent; and are capable of making a very considerable quantity of salt, supposed about a hundred bushels a day. Also a good dwelling house, a salt house, a store house and stables, a large covered cistern, 100 feet long, 22 feet wide and 2 feet deep; the whole erected on a healthy and pleasant point of land. The unexpired term of the lease thereof, and the privilege of cutting wood within one mile of the works, at the moderate price of one bushel of salt for thirty cords of wood, is also for sale. The works are supplied with water from the bay (of the best quality) which is pumped into the cistern. . . . .The sale to continue from day to day until the whole are sold.

The Pennsylvania Gazette Sep't. 13, 1780

Hopkins briefly remarks in his Journal that "the works have been set up at Vendue and was bid in for the owners." The last entry in the Journal is October 20, 1780, which is the last bit of information about these works. (Authors' note: the balance of the Journal has been completely destroyed.)

In the Journal of Aaron Leaming‡ there are a few brief notices about his works.

May 23, 1777 Mr. Hand and Mr. Godfrey went on the beach to set up my saltworks. 6 kettles, viz. 3 of 32 gall. & 3 of 42 gall. each about 222 gall. the whole and (illegible . . . . .) I and Phil Godfrey went out to make salt.

1777 July 18 Mr. Holmes and I having concluded to increase our saltworks Persons Leaming and he is preparing to set out to buy kettles. Our aim is to buy 3 tons for him and 2 tons for me and one ton for Jesse Hand. . . . .

There are several more entries about the purchase of the iron, its cost, cartage, and other expenses, aside from that there is nothing more about his works, and, unfortunately, he says nothing of his output or how long he carried on the business. It will be noted that he speaks of kettles, not pans, as in the other works. Also the general capacity of these kettles corresponds with that of the kettles which are in the museum at Cape May Court House, New Jersey.

Information of the Union Saltworks is sketchy and incomplete. In March, 1777, the Legislature passed an act "to exempt ten men to be employed at the Union Saltworks. . . from the Militia." In April of the following year Savadge wrote to the Executive Council of the destruction of the Union Saltworks. This report is amplified in a newspaper account.

". . . . .They (Authors' note: the British troops) arrived off Squan where the troops landed and marched up to some very considerable saltworks erected there by the Rebels which they entirely demolished."

New York Gazette and Weekly Mercury, April 13, 1778

These works were soon rebuilt. In March, 1779, the Union Saltworks advertised for "Woodcutters for whose labour a generous price will be given," and at the end of the month the works were put up for sale.

SALT WORKS, ETC. FOR SALE

To be sold at public vendue, on the 30th day of March on the premises these valuable works known by the name of the Union Salt Works, on the Manasquan River . . . . . to-gether with all the utensils. . . . .The Works consist of a boiling house, about 90 feet long and 30 feet wide, in which are five copper and four iron pans, all of which are fixed in the best manner for the business of boiling salt. (Author's Note: there now follows a detailed description of the pans.) Adjoining to the boiling house is a convenient store house capable of containing 800 bushels of salt and contiguous thereto is a pump house in which are two pumps almost new, by which the water from the bay is conveyed either immediately into the pans or into a covered cistern holding about 150 hogshead, at times when the water is the saltiest and from thence led into the pans. . . . .The works and buildings are pleasantly situated on the river aforesaid about one mile from the main ocean commanding a fine prospect and in short these

* The discovery of the ruined dam was privately communicated to the authors. The deed for the transfer of the saltworks to Thompson is the property of Mrs. James Irons of Tom's River, New Jersey.

† The Journal of Thomas Hopkins of the Friendship Salt Company, New Jersey, 1780, is in possession of the Pennsylvania Historical Society, Philadelphia.

‡ The Journal of Aaron Leaming is in the Pennsylvania Historical Society. Leaming died in 1780 and his will, which was drawn up in 1775, contains no codicil for the disposition of the Saltworks.

works are allowed by competent judges who have viewed the different works along the shore to be equal if not superior to any in this State.

New Jersey Gazette, March 24, 1779

A more general view of the extent of the various works is reflected in several newspaper notices, letters, and in a few local histories.

To be sold a complete set of Saltworks at Great Egg Harbor, consisting of 4 large pans and several kettles, supposed to contain three or four thousand gallons, to-gether with the buildings, salthouse, drying house, dwelling house and stables; . . . . . any person inclining to purchase may apply to FRASIER KINSLEY at Great Egg Harbor or to Peter January in Philadelphia.

The Pennsylvania Evening Post, July 21, 1778

✦ ✦ ✦ ✦ ✦ ✦

Extraordinary Wages

and exemption from serving in the Militia

and still higher wages, without such exemption will be given to a few choice wood cutters and laborers, to be employed at the Saltworks, about eighteen miles southward of the Forks of the Little Egg Harbor and two miles northward of Absequan River. Apply to the said works to

NATHANIEL PETTIT

Private annals of the Pettit family, Burlington, N. J.

✦ ✦ ✦ ✦ ✦ ✦

A COMPLETE SET OF SALT WORKS, commonly known by the name of Kennedy and McCulloh's situated about three miles from Great Egg Harbor Bar. . . . .The Said works to be sold for cash only. Attendance will be given at said time and place by

JOSEPH MCCULLOH

Pennsylvania Packet, August 6, 1778

✦ ✦ ✦ ✦ ✦ ✦

On Falkinburg's Island in Little Egg Harbor was a saltworks which was advertised for sale by Thomas Heston and Co. in the Pennsylvania Packet of April 24, 1779.* From the notice it is also a "Valuable Saltworks" and "the situation is healthy and pleasant and allowed by judges the best adapted for profitable works along the shore."

One of the authorities on salt was a Dr. Robert Harris of Philadelphia (?) and Townsend's Inlet, New Jersey. He made gunpowder for the Committee of Safety of Pennsylvania and that group loaned him money for a powder mill and forwarded saltpeter to him. At Townsend's Inlet he operated extensive saltworks and accounts of them in the local histories are indefinite and vague. In answer to a proposal from the Executive Council he set forth conditions for a partnership concern, among which there is one item which fixes approximately the date of his works.

Item 9. That the commencement of this partnership concern be as soon as all the works are ready to order. That Dr. Harris to retain the proper use and benefit of his own works until that time.

August 9, 1777, Philadelphia.

* The Pennsylvania Historical Society has a letter dated November 20, 1779, from the supposedly (?) new owner, Jacob Falkinburg to Thomas Heston. The letter is remarkable in its illiteracy.

There is no record of the outcome of the proposed partnership. Savadge in one of his numerous letters said that ". . . Dr. Harris has been at the works and seen them all over and can, I make no doubt, give Council a very satisfactory account of them, he having a very considerable work of his own and consequently a competent judge of them."

James Randolph advertised December, 1779 ". . . for sale, a very good farm the situation being very convenient for saltworks near Tom's River." On March 20, 1782, Randolph's will was advertised for probate, ". . . one plantation at Mosquito Cove on Tom's River . . . with a convenient fishing place and saltworks." This is all which has appeared about Randolph's venture in saltmaking.

Of the many other works their exact location and ownership is guesswork. Knowledge of some can only be obtained from meager and inaccurate newspaper notices. A letter by an obscure person states that ". . . numerous small saltworks were destroyed by the storm on our coast." (The letter refers to Barnegat Bay in March, 1778.) Newspaper accounts refer to "several small works on our shores were destroyed by the British." The lifespan of the saltworks was perhaps six or seven years and during their life filled a great need. They disappeared rapidly, and it is small wonder that they are almost forgotten.

The owners of the saltworks were in constant fear of raids by the British. Sir Henry Clinton in a letter to Lord Germaine in October, 1778, specifically states that an expedition should be sent to Egg Harbor to destroy the saltworks.[3]

In the middle of the month it was reported to Sir Henry from Little Egg Harbor that ". . . an opportunity offered . . . to penetrate some miles into the country and destroy three saltworks." Thomas Hopkins in his Journal noted the appearance of armed ships in the Bay and the people of Cape May County petitioned Governor Livingston for protection of their saltworks and homes (March, 1778). The day after the destruction of the Union Saltworks (*q. v.*), the works at Shark River were razed.[4] There is also reported that a salt works at Shrewsbury[5] were destroyed by the British who were operating in the neighborhood. Samuel Brown's works at Forked River were set on fire by a marauding band of refugees and he himself barely escaped with his life.[6]

The Pennsylvania Saltworks at Tom's River were continually harassed by the British and by roving bands of refugees. It has been pointed out that Savadge asked at different times for ships, troops, and artillery to protect the saltworks. In every case this was a precautionary measure because of the "nearness of the enemy." In April, 1778, just after the destruction of the Union Saltworks Savadge wrote to the Council ". . . they intend these works a visit very

[3] Document No. 1176, B. F. STEVENS, Facsimiles.
[4] "New Jersey Gazette," April 15, 1778.
[5] "New York Gazette and Weekly Mercury," November 10, 1777.
[6] "New Jersey Gazette," June 5, 1782.

soon." Another time when he requested protection he wrote ". . . he feared an attack." After the expedition against the Egg Harbor works a newspaper reported "they (the British) have it is said bent their course toward Tom's River in order to destroy our Saltworks." In several letters Savadge reported the visits of marauders in the immediate neighborhood but in each case definitely said that the works were untouched. In the accounts in several local histories it is repeatedly stated that the Saltworks at Tom's River were destroyed by the British Troops. In the Waste Book of the Saltworks, in the copious correspondence between Savadge and the Council of Safety, and in newspaper reports there is no notice of either an attack upon them or their destruction.

With the scarcity of salt came the realization to the colonists of its importance and of the works which produced it. Advantage was taken of this necessity. Salt became a medium of exchange, and it was offered for everything imaginable. The price of salt was so variable and exorbitant that the Legislature of New Jersey in December, 1777, passed an act that ". . . salt of home manufacture, 55 pounds to the bushel, £3, 10, 0 at the works and 6d per bushel fore very mile of land carriage to the place of sale or consumption for profit and carriage." A few months after this act was passed a case of profiteering appeared before the Committee Chamber of Morris County. A judgment was entered against two men, Curtis and Norris, because ". . . the said Curtis in selling salt, tea, etc. at an exorbitant price and unreasonable profit and the said Norris in selling salt in like manner." A complete boycott of these two men was ordered by the Committee.

Property owners were quick to capitalize on this infant industry. Owners of land on bays and rivers advertised their land for sale ". . . as well situated for manufacturing salt as any in New Jersey." (There are a number of such notices.) Others offered their land for sale because of its proximity to a saltworks. As shortlived as this enterprise was, it is easy to see how important it became in the lives of the people.

Unfortunately, there is no plan of any of the Colonial Saltworks and only a meager description of the process of making salt. From the notices and descriptions for the sale of the numerous works, from Journals, and from Savadge's letters important facts stand out. Aaron Leaming's works were set up on the beach, while others were on bays and rivers. He used kettles, while the works farther north used pans of greater volume. The Union Saltworks had one pan of 170 gallons and three others 520, 580, and 840 gallons, respectively. Other saltworks used pans of the same general capacity. Pumps to convey the brine were operated by either hand power, windmill, or both. Some of the storage ponds were filled by pumps and others by opening sluice gates at high tide which permitted the sea water to enter the pond through ditches. Solar evaporation took place naturally in the ponds and it is definitely known that two of the works had sunpans (Pennsylvania and the Friendship Works). In many cases covered cisterns were used to hold either the concentrated brine from the sunpans or the freshly pumped sea water. Salt baskets are mentioned occasionally, and it is supposed that they were used in the purification process.

The following notice which appeared in the "New Jersey Gazette," February 4, 1778, is of interest because it shows an attempt to make use of a by-product.

> Wants to engage in partnership with some Gentleman that is inclined to carry on the works for making Epsom's salt at Great or Little Egg Harbor, a young man will constantly attend and carry on the business. . . . .Likewise, any young man that would be glad to serve any Gentleman as a clerk to iron works or clerk and manager at public saltworks being capable of the business. For further particulars enquire of the printer.

The process of making salt from sea water was very simple. It has already been mentioned that the sea water was led into large ponds by pumps or through sluice gates at high tide. These ponds acted as reservoirs and more or less natural concentration of the brine took place in them. If sunpans were used, the brine was led into them by a series of gates and sluices from the pond. The final concentration of the brine took place in the boiling house or saltern. If sunpans were not used, the brine was pumped from the pond through wooden pipes or troughs into the boiling pans in the boiling house. The boiling house was a large covered building open on the sides.

When the Executive Council of Pennsylvania was considering plans for the construction of the works at Tom's River they applied to a Mr. Hampton of Virginia for aid. A letter from him to the Council briefly describes the essentials of a primitive works, and it is the only contemporary authoritative description of saltworks pertaining to New Jersey which has come to the author's notice. It is dated May 29, 1776.

> There is but one Pan erected yet, which is composed of a great number of iron plates; each put to-gether by screws. Hammered Plates would certainly be better for two reasons; the cost, requiring from their necessary thickness a much greater quantity of Fuel and the uncertainty of getting them to fit properly, to which I might also have added a third—the weight. The whole is supported on cast iron beams over a large Furnace which must have two doors on the same side, the bottom of the Furnace mostly iron grates to give air and let the ashes through, the Foundation, Sides, etc. Brick and Mortar with a slight covering to the whole. The Brine is at full tide let into a large Pond by a Gate where it remains till a greater part of the impurities subside, when it is raised by pumps and conveyed through troughs to the Pan, which is about 15 or 18 inches deep and contains about 2500 Gallon. There is frequently fresh quantities of water added while boiling, and the pan is generally drawn or cleared of salt twice a week (tho' I'm told and indeed believe it to be practicable to do it, three Times) each drawing is from 20 to 25 Bushels of salt according to the strength of the Brine which has increased lately, and some time ago from Experiments made produced about one twenty sixth part of salt. Mr. Tait, as well as I recollect says that one boiling or Pan of salt as he calls it will consume about 4 cords of Wood, but apprehend much depends on the placing the Pan at a proper distance from the Grates. There are Public works to be erected here and at the next County for making salt by the sun.

The removal of the magnesium sulfate from the salt as it was taken from the pan depended on the respective

solubilities of the two salts. This was the method common to that period, and it can be assumed that it was used by the Colonial saltmakers. Beesely and Saltar in their respective histories give a method of making salt on the Jersey coast. These two methods are obscure and scientifically unsound. In no way do they fit the known facts of the saltworks. No attention need be paid them.

As the Revolution drew to a close the numerous saltworks ceased operations, one by one, and were soon forgotten. A ninety-two year old resident of Forked River told the author that he used to go duck hunting in the "Saltpond," but he never knew how the name originated. This may have been Samuel Brown's Saltpond; who knows? It is typical of the complete obliteration of this short-lived important enterprise.

A brief passing word must be appended in regard to the later saltworks. There were a few sporadic attempts to resurrect the industry during the War of 1812. Works in the neighborhood of Atlantic City are alleged to have operated for a number of years. They were strictly local in character and were of no importance industrially.

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The author wishes to acknowledge his indebtedness to the many friends who aided him in this three-year search for the Saltworks. Particularly must be mentioned The Pennsylvania Historical Society, Mr. Alfred Rigling of The Franklin Institute, and Mr. Edward Post of the Cape May Court House Museum.

In no way can the author make adequate public expression to his wife for her assistance, coöperation, and kindly criticism throughout the entire investigation of these "Saltworks."

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# DEMONSTRATION *versus* LABORATORY ONCE AGAIN

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*This article describes a laboratory procedure which is neither the standard laboratory nor lecture demonstration method but which seems to offer the advantages of each while lacking some of their disadvantages. It involves pupil demonstration by a system of rotation which gives sufficient practice in laboratory technic to insure the gaining of manipulative skill for each student, yet commands a better degree of attention and retention by the class than teacher demonstration seems to produce.*

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IN THE face of the considerable literature, at times amounting almost to a flood, which has developed in recent years on the subject of the relative value

of the lecture demonstration and the individual laboratory method in science,[1] and dating back at least to 1918,[2] it would appear that there should be considerable hesitancy in adding to the total. There need be at any rate no doubt as to the issues involved, since the holding by the American Chemical Society of the symposium on the subject at its New York meeting in 1935.[3] The reasons for the continuance of the debate seem to be on the one hand based on the claims by the proponents of the demonstration method of a greater cost in time and money and greater administrative difficulty of the laboratory method, when viewed in the light of the apparent fact that tests prove the educational results to be no better, and perhaps not so good; whereas the opposition clings to a "not proven" verdict and cites the accepted values of learning by doing, the acquisition of operative technics and first-hand understanding of scientific phenomena.

But neither in the reports of the New York symposium, nor in the literature referred to, does there appear to be suggested a procedure which is eminently practical and which seems to combine the salient advantages of both the laboratory and of the demonstration method while lacking many of the disadvantages of each. Two methods which have been described[4] and which appear to be most nearly like the one now to be considered, prove on comparison to be clearly different in several particulars. The present approach, developed by the writer while teaching science in a California high school, has now been in use for several years in that and neighboring schools; and furthermore it has met with an enthusiastic reception when introduced into college courses for the training of teachers of science, conducted by the writer for the past few years.

It is quite likely that the method would not have originated in just the way it did, and certainly not at the time it did, had it not been for that great calamity, the Long Beach earthquake, which disrupted so many educational programs in California. As a result of that cataclysm and the general exodus which was soon thereafter ordered by school boards from buildings considered unsafe for occupancy, this particular science teacher found himself evicted almost overnight from his department headquarters, consisting of separate and well-equipped laboratories for chemistry and physics, with an additional lecture room, and presented in their place with a one-room shack fifteen by twenty-four feet; the furniture consisting of chairs and a half-dozen deal tables, one kitchen sink fastened to the wall, and a demonstration table nearby supplied with one gas jet, and nothing else. Here surely the obvious thing to do was to apply the lecture-demonstration technic, and, furthermore, no one could rightfully complain if the results were somewhat unsatisfactory, in view of the handicaps. But as a result of a feeling that perhaps some other alternative was worthy of a trial, a compromise was attempted which soon developed into a permanent and highly satisfactory program.

Using the subject of chemistry for the purpose of illustration, the procedure in brief is as follows. The class is divided into groups of two pupils each, and they are assigned in order the various experiments appearing in the standard manual. At the laboratory period scheduled, the two students undertake full responsibility for the performance of the experiment while the remainder of the class watches from seats nearby. The work is carried out just as it would be by the customary laboratory method, except that from time to time the demonstrators comment or make explanations to the observing group as occasion arises. Those watching take notes as if performing the experiment themselves, following the instructions and answering the questions given in the manual. The teacher comments or offers emergency help if the need arises; otherwise he remains a silent spectator.

The following laboratory day another group in turn takes charge, the first demonstrator group then joining the class of observers. This goes on until everyone has had his turn, when the rotation is repeated, with the result that in an ordinary-sized class of twenty to thirty-five, each student has appeared as demonstrator during the course of the year some five to eight times. It usually occurs that the students appointed come around in advance of the time and make some preparations, or even run through the whole experiment briefly, to insure a successful demonstration the following period. It is not necessary to urge them to do this, for obvious reasons.

Now what merit has this over the teacher-demonstration method, or, rather, some may ask, is it not obviously inferior to that method because of the necessarily poorer performance of students? The answer is quite definite and unmistakable in the minds of those who have conducted the work by this plan. First, what of the effect on the observing group? It will be agreed that there is a vital difference between this and the "child-passive" attitude of the student who with varying degrees of boredom watches the demonstration of the teacher. His natural attitude in this case is to take it for granted that the experiment will be performed correctly, and his own part is only the rather disagreeable task of recording a foregone set of conclusions. But not so when two of his fellows perform the same experiment. Now there is no assumption that all will go well to a predetermined end. Past experience, perhaps his own recent embarrassment, warns him that at any time something may go wrong or

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[1] PAYNE, V. F., "The lecture demonstration and individual laboratory methods compared. I. The literature," J. CHEM. EDUC., **9**, 932–9 (May, 1932); BARGER, T. M., "Effectiveness of the individual laboratory method in science courses," *ibid.*, **12**, 229–32 (May, 1935).

[2] WILEY, W. H., "An experimental study of methods of teaching high school chemistry," *J. Educ. Psychol.*, **9**, 181–98 (Apr., 1918).

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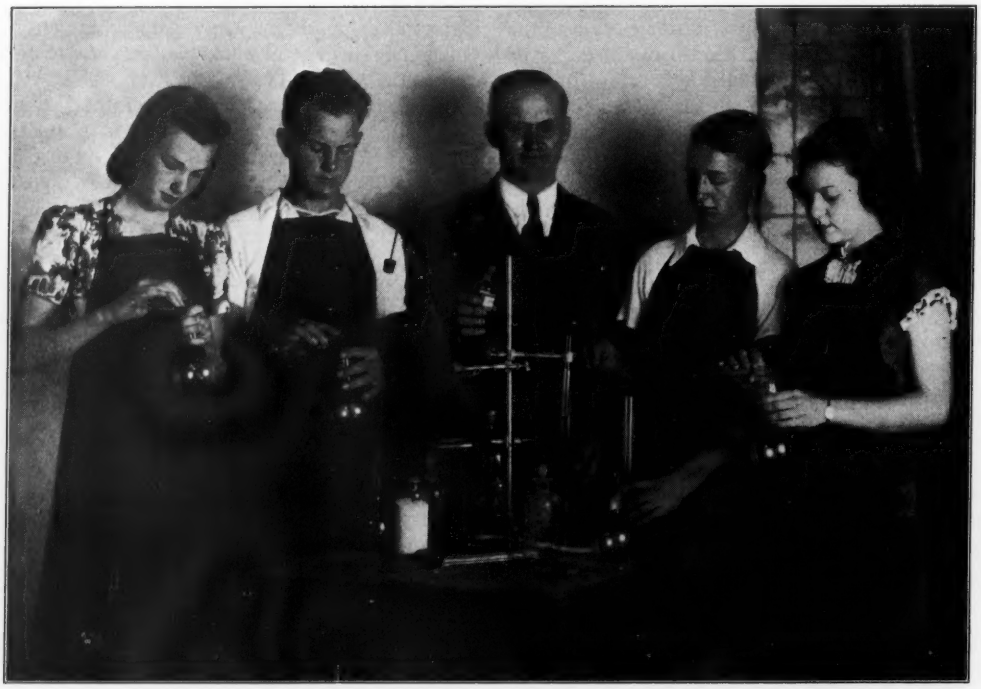
[4] NASH, H. B. AND M. J. W. PHILLIPS, "A study of the relative value of three methods of teaching chemistry," *J. Educ. Research*, **15**, 371–9 (May, 1927); BARGER, T. M., *op. cit.*

a mistake may be made; and whether from a Roman Forum complex or from a natural desire partly to justify his own previous failings, there is a sustained alertness which makes both for more careful work on the part of the experimenters, and a better retention of the points involved in the experiments, on the part of the watchers.

And what of the demonstrating team? Here can be seen the greatest advantage of all. Under the circumstances described there is little opportunity for "sloppy" performance, the asking of one's neighbor what the proper result was: "Oh, it's red is it? I thought it was green, but maybe my test-tube was dirty. Did Mary get red? Well, we'll put it down red." A constant check is operating against that careless technic which so frequently in the usual crowded laboratory class escapes the watchful eye of even the most diligent of teachers. In addition to the stimulus of teacher watching, we have the far greater stimulus of class observation. Here no fudging goes; without any teacher encouragement, the class is alert to detect the slightest departure from correct work. Those teachers who have tried it out feel confident that the opportunity for skill in technic under the strong impress of the conditions is equal to that acquired over a much longer period of standard laboratory practice.

Thus we seem to have all the advantages of economy of time and material which are offered as a chief argument for the lecture-demonstration method, compared with most of the end results of the laboratory method, including certain apparent points of superiority. At least it should justify a trial on the part of those who are investigating this field. Furthermore, when used in teacher training courses, there is no necessity for the development of a new technic to meet standard high-school conditions, a point to be considered when making comparison with other laboratory substitute proposals. It may be that out of an emergency, something worthy of perpetuating has arisen.



WINNERS OF 1938 SUPERIOR CALIFORNIA CHEMISTRY CONTEST

LEFT TO RIGHT: ELAINE SPANGER, IRWIN LAUPPE, C. E. HOLEN—INSTRUCTOR, PAUL BRUNNER, CLAIRE SANDROCK

Teams from Roseville Union High School, Roseville, California, have won these contests, which are held annually under the auspices of the Sacramento Valley Division of the American Chemical Society, in 1930, 1931, 1932, 1934 and 1938. Members of the Roseville teams won the individual trophy in 1929 and 1930.

After the 1938 contest a reception, "Chemical Show," was held, and a short lecture, "Romance of Chemistry" was given. These had been prepared by Professor A. T. Bawden of the College of the Pacific. Through these contests the Sacramento Valley Division hopes to stimulate a greater interest among high-school students in the exact sciences.

WILLIAM O. BROOKS
A. T. BURTSELL
R. K. CARLETON
TENNEY L. DAVIS
C. K. DEISCHER
J. HOWARD GRAHAM
B. CLIFFORD HENDRICKS

# ABSTRACTS

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## KEEPING UP WITH CHEMISTRY

**Americana Buna.** ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **140,** 1 (Oct., 1938).—German synthetic rubber known as "Buna" is attracting attention in this country because one type of Buna rubber possesses properties reported to be superior in some respects to our American product, Neoprene, an excellent synthetic rubber. Buna rubber can be compounded on rubber milling machines and vulcanized in the same manner as natural rubber. The principal raw material for the manufacture of Buna N is butadiene, a highly unsaturated gaseous hydrocarbon, made in Germany from acetylene derived from calcium carbide and in Russia from alcohol. Buna rubber is a development of the German I.-G. and is patented in the United States. It is sold in this country under the name, "Perbunan." Crude rubber sells for about sixteen cents a pound, while Neoprene costs about sixty-five cents a pound. In most special fields the higher price of synthetic rubber is not prohibitive because of its extraordinary resistance to oil and gasoline, superior resistance to oil and gasoline, and superior resistance to abrasion. It is highly probable that it could be produced here profitably. G. O.

**Regional laboratories.** ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **140,** 3 (Oct., 1938).—The regional laboratory program of the Department of Agriculture for the development of new scientific, chemical, and technical uses for farm products is one of the most interesting and far-reaching research projects for the year. The plan provides $1,000,000 yearly for each of four regional research laboratories, one in each major farm-producing area. The Northern laboratory will be devoted to corn, wheat, and agricultural waste products; the Southern laboratory to cotton, sweet potatoes, and peanuts; the Eastern to tobacco, apples, Irish potatoes, milk products, and vegetables; and the Western to fruits (other than apples), vegetables, Irish potatoes, wheat, and alfalfa. Efforts will be made not to duplicate the present work of the Bureau of Chemistry and Soils, nor that of industry, or institutions. The personnel of eight hundred to one thousand technicians will be drawn entirely from Civil Service. G. O.

**Resistoflex.** ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **139,** 4 (Aug., 1938).—Resistoflex is a new synthetic tubing so flexible that it can actually be tied in a knot. This resin is made from polyvinyl alcohol and was created specifically to meet the demand for a material unaffected by gasoline, oils, and organic solvents. It is claimed to be the only synthetic resin completely insoluble in gasoline, oil, the aliphatic compounds and aromatic hydrocarbons, as well as ethers, esters, alcohols, and ketones. It has been sold abroad for several years. It has been successfully used in many industrial applications, chiefly in the fuel and brake lines and lubrication systems of automotive equipment; in Diesel engines and aircraft; in the conveying of solvents and mineral and vetetable oils in the chemical industries; in hydraulic lines; and in fuel and oil-handling equipment. G. O.

**Why use the bean?** ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **139,** 3–4 (Aug., 1938).—A Wisconsin manufacturer is now offering vanillin made from lignin from spruce or other coniferous wood. The new vanillin is a pure white, stable crystalline material of U.S.P. grade or better with an aroma quite indistinguishable from the vanilla taken from the bean. Synthetic vanillin has for some time been produced from coal tar or a constituent of clove oil. The new process produces vanillin simply and directly from live wood. G. O.

**Cancer-producing hydrocarbons.** L. F. FIESER. *Rept. New Eng. Assoc. Chem. Teachers*, **39,** 178–84 (May, 1938).—Cancer stands next to heart disease as a cause of death and is the outstanding medical problem of the day. More accurate diagnosis or better control of other diseases may account for the jump from seventh or eighth place rather than an increase of cancer itself. Skin cancer was noted about thirty-five years ago as prevalent among coal-tar workers. Yamigawa and Ichikawa during the World War found that the application of certain coal-tar fractions to the ear skin of rabbits caused tumors. Soon a number of tars were found to be carcinogenic. Mice were found to be especially suitable for test purposes. Work at the Research Institute of the Cancer Hospital in London with fluorescent spectroscopy gave clues as to the particular tars likely to be carcinogenic. A large number of synthetic hydrocarbons have been studied in search of the active carcinogen. Since anthracene derivatives possess striking fluorescent properties special attention has been given to compounds of this series. In 1930 it was discovered that 1,2,5,6 di-benzanthracene produces cancers when applied to the skin of mice. In 1933 English investigators isolated from coal tar a hydrocarbon called 3,4-benzpyrene with high carcinogenic properties and a formula related to anthracene. Wieland and Dane, working in Munich, in the same year on bile acids degraded desoxycholic acid and isolated a yellow aromatic hydrocarbon of the anthracene series which they named methylcholanthrene. In later work at Harvard methylcholanthrene was obtained by the degradation of cholic acid, the most abundant acid constituent of the human bile. That substances normally present in the body can be converted by chemical transformations in the laboratory into an actively carcinogenic hydrocarbon suggests the hypothesis that cancer may in some cases be caused by the abnormal metabolic production of methylcholanthrene or a related product from a bile acid or cholesterol. Active work is being carried on at Harvard in preparing related hydrocarbons and testing for carcinogenic properties on mice. W. O. B.

**Some recent developments in catalysis.** R. K. CARLETON. *Rept. New Eng. Assoc. Chem. Teachers*, **39,** 206–8 (May, 1938).—Between 1896 and 1916 contact catalysts began to enter the industrial field. Ten years later a new era began with the development of synthetic methanol and higher alcohols. Nickel is a most important catalyst, nearly one-half a million pounds being used for catalytic purposes in 1936, about seventy per cent. of this for hardening fats. Cobalt is a catalyst that is unique probably due to the instability of its oxides. Cobalt oxide is the most efficient catalyst for the oxidation of ammonia and will also promote effectively the oxidation of HCN to NO, an important fact for gas masks. Cerium and other rare earths in the form of oxides have long been known as catalysts, particularly in the case of the Welsbach mantle. The rare earths have been found to be effective catalysts in oxidation reactions such as the oxidation of benzene to phenol. All four halogens are good catalysts. Aluminum chloride is the most interesting of the metal halides for catalysis promoting the polymerization of olefins. The success met with oxides of metals as catalysts, notably oxides of zinc and chromium, has given chemical engineers a tool of great usefulness. In spite of the great increase in the use of substances for catalysis, the way catalysts act—the "how" of the process is still not very well known, although much work is being conducted along this line at present. W. O. B.

**Some newer aspects of silicon chemistry.** W. C. SCHUMB. *Rept. New Eng. Assoc. Chem. Teachers*, **39,** 191–3 (May, 1938).—Silicon shows numerous formulary resemblances to carbon but sharp differences in the properties of analogous compounds. Silicon halides such as $SiCl_4$ show a great tendency toward hy-

drolysis, yet corresponding compounds of carbon do not. Next to carbon, silicon exhibits the greatest tendency toward chain and ring formation, although the tendency falls far short of that shown by carbon. Schwarz and Meckbach recently announced the longest known inorganic chain compound in $Si_{10}Cl_{22}$ which was prepared by the interaction of $SiCl_4$ and $H_2$ in a "hot-cold" tube. It is supposed to possess a branched chain structure. If silicon cannot saturate all four of its valence bonds it shows a tendency to unite with itself—to polymerize. Thus the polysilenes $(SiH_2)x$ are highly polymerized solids with chains of silicon atoms and do not represent a case of true bivalent silicon.

The use of X-ray analysis to show the structure of crystalline silicate minerals is the most striking advance in silicon chemistry in recent years. Formerly, it was the custom to relate these silicates to hypothetical silicic acids which experimental work failed to produce. The X-ray method shows that the invariable unit of the silicate structure is the tetrahedron, composed of a silicon atom surrounded by four oxygen atoms. These tetrahedra may be joined to one another at the corners only (never edges or faces). The metallic atoms, Ca, Na, Mg, and so forth, occupy positions in the interstices. Thus the various silicate types arise; the orthosilicates (independent tetrahedra), pyrosilicates (paired tetrahedra), chains and rings of tetrahedra in metasilicates, sheet-like structures in the disilicates, and the silica type itself (as in quartz), with a three-dimensional network of tetrahedra. These five types are subdivided into families, groups, and species. W. O. B.

**Polymerization and its economics.** W. A. KOEHLER. *Chem. Met. Eng.*, **45**, 412–5 (Aug., 1938).—Two developments in the petroleum refining industry have helped greatly to increase the gasoline yield. One is the commercial cracking process and the other is the polymerization process. The latter has a potential supply of more than fifteen per cent. of the motor fuel output of the United States. The gasoline formed in the cracking process is passed through a stabilizer to remove most of the methane, ethane, ethylene, propane, propene, butanes, and butenes. The propane-propene and butane-butenes are the raw feed for the polymerization unit. Three types of polymerization units are now in use: (1) Uses heat and pressure only; (2) uses a catalyst; and (3) uses a catalyst followed by hydrogenation. All produce high octane gasoline. The polymerization process may be looked upon as the reverse of cracking and can be so regulated as to produce everything from hydrogen gas to lubricating oils and heavy tars. The net cost of polymer gasoline varies from 3.5 cents to 5.5 cents per gallon, depending on the size of the plant and the value of the raw fuel. J. W. H.

**Contrasts in fiber manufacture.** T. R. OLIVE. *Chem. Met. Eng.*, **45**, 409–11 (Aug., 1938).—The object of this article is to compare the manufacture of glass fiber with rayon. While glass fibers are unlikely to encroach on rayon markets they have some striking similarities and dissimilarities in manufacturing technic. It took thirty years to assure the manufacturing future of rayon but only three years for glass fiber. In rayon the investment per pound of output is considered high in the process industries, while for fibrous glass this investment is not much in excess of that required for the production of some of the more delicate glass forms.

Fibrous glass is being produced with individual filaments of 0.00025 in diameter while the various rayons vary from 0.0004 to 0.0005 in diameter.

Fine glass fibers have a tensile strength comparable to that of steel. The space required by a single 50-spinneret viscose spinning machine would provide room for fibrous glass equipment turning out several times the poundage. For glass there is no extensive chemical building, no coagulating bath recovery equipment, no dryers, no water problem or tremendous water consumption, no washing, no bleaching, and little need for inspection. Fibrous glass, however, does have the problems inherent in high temperature operations. Molten glass, under a constant head in the melting furnace, discharges continuously through a spinneret comprising a row of thirty-two tiny orifices drilled in an electrically heated orifice plate. Directly below is a special form of steam jet discharging high-pressure superheated steam in such a manner as to seize the molten glass threads and drag them down, thus decreasing their diameters. The individual fibers are then projected downward through a gas flame for drying. Then they strike a chain belt conveyor from which they are picked up, directed through guides and wound on a tube. J. W. H.

## HISTORICAL AND BIOGRAPHICAL

**Bicentenary of the death of Herman Boerhaave (1668–1738).** ANON. *Nature*, **142**, 504 (Sept. 17, 1938).—The Dutch Medical Association, the Leyden Faculty of Medicine, and the Society of the History of Natural Sciences of Leyden have recently observed the two-hundredth anniversary of the death of Herman Boerhaave by visits to his home and to the old St. Cecilia Hospital, where he used to give clinical lectures, and by the publication of a commemoration volume. Boerhaave's best known chemical work, "Elementa chemiae," was published in 1724. He died on September 23, 1738. M. E. W.

**Professor J. J. Abel (1857–1938).** J. A. GUNN. *Nature*, **142**, 242–3 (Aug. 6, 1938).—The late Professor J. J. Abel, who died on May 26, 1938, "was one of the few surviving links from the beginnings of pharmacology as a separate discipline." For nearly forty years he served as professor of that subject at the Johns Hopkins University. In 1909 he founded the *Journal of Pharmacology and Experimental Therapeutics*, the first pharmacological journal to be published in English.

His early investigation of the occurrence of aliphatic sulfur compounds in the animal body helped him later in the successful crystallization of insulin, for fractions of insulin preparations contain labile sulfur in proportion to their hypoglycemic power. "He was one of the earliest workers on hormones, and succeeded in obtaining an active principle of the suprarenal gland in the form of a monobenzoyl derivative which he called epinephrine. Later Takamine obtained the free base, adrenaline. The determination of the chemical constitution of adrenaline and the discovery that it was a relatively simple body gave an impetus to that study of the constitution of other hormones which has developed so rapidly in recent years."

Abel and Rowntree found "that phenolphthalein was excreted solely by the kidney, and this led to its use later as a test for the functional activity of the kidney. Halogen substitution products of phenolphthalein were found to be excreted in the bile only, and this led to the development of tests for liver function by such compounds."

Even after his retirement in 1932 Professor Abel continued his researches until the close of his life. M. E. W.

**Robert Warington (1838–1907).** ANON. *Nature*, **142**, 323 (Aug. 20, 1938).—August twenty-second marked the centenary of the birth of the great English agricultural chemist Robert Warington. As a boy he learned chemistry from his father, Robert Warington, and from the lectures of Faraday, Brande, and Hofmann. At the age of twenty years he worked under Sir John Lawes at the Rothamsted experiment station as an unpaid assistant, and a year later he bec me assistant to Frankland at South Kensington. He published many memoirs on the nitrification of the soil. His most successful work was entitled "*Chemistry of the farm.*" M. E. W.

**Dr. J. W. Mellor (1869–1938).** A. T. G. *Nature*, **142**, 281–2 (Aug. 13, 1938).—As a youth Dr. J. W. Mellor worked in a boot factory in New Zealand and studied in the night classes at the Dunedin Technical College. When he later became the first principal of the pottery department of the North Staffordshire Technical College, he understood the difficulties of his night school students and became very popular with them. He raised the status of the Ceramic Society "from a purely local association to that of an international institution."

Professor Mellor wrote more than one hundred papers on ceramics, the first in 1904 and the last two months before his death, which occurred on May 24, 1938. He was "quick to realize the importance of refractory materials to the well-being of an industrial nation."

His monumental sixteen-volume work "A comprehensive treatise on theoretical and inorganic chemistry" was completed in 1937. "To his few intimate associates, the completion of these volumes is almost beyond comprehension. They know that he wrote every word and every reference." Professor Mellor also published "Higher mathematics for students of chemistry and physics," "Chemical statics and dynamics," "Modern inorganic chemistry," and "A treatise on quantitative inorganic analysis." "His book of cartoons, 'Uncle Joe's Nonsense,' revealed his ever-youthful spirit." M. E. W.

# RECENT BOOKS

LIBRARY GUIDE FOR THE CHEMIST. *Byron A. Soule,* Sc.D., Assistant Professor of Analytical Chemistry, University of Michigan. McGraw-Hill Book Company, Inc., New York City, 1938. xiii + 302 pp. 55 figs. 14 × 20.5 cm. $2.75.

This exceedingly practical book is designed by the author to train chemists in library technic and to assist them to acquire skill in the use of the available chemical publications. Since the book is a guide for the chemist in the library, the author states that he does not pretend to include a complete bibliography of source material but he wishes rather to emphasize the methods of using the more important books and journals.

The first two chapters discuss the arrangement of a library and the card catalog from the standpoint of the chemist who uses them, and not that of the librarian who takes charge of their organization. A chapter devoted to biographical material follows. The next four chapters present methods of using in the most efficient manner the periodicals publishing original papers, the abstract journals, the review serials and monographs and the encyclopaedias. These types of publication represent the gradual condensation of chemical information from the original through three stages of secondary source material. Patents and government publications are the subjects of the remaining chapters except for the last, which is an excellent discussion of the schemes for making literature reports.

The outstanding contribution of the book is the assembly of ideas and devices which give definite practical assistance. There are fifty-five tables which indicate in compact form, summaries of the contents of the important chemical publications. There are suggestions relating to the evaluation of the literature, organizing bibliographical investigations, preparing accurate, concise reports and directions for the standard types of reference writing. The lucid explanation of the use of the keys to such compilations, as formidable to the beginner as the International Critical Tables and Beilstein, is very valuable. The chapters on patents enlighten the reader not only on the problem of how to find a patent, but also on how much he should know about patents in the course of his professional career. Since it is approximately a decade since the publication of a similar book, the bibliographical material of Professor Soule's volume bridges the gap between that older period and the present.

This book is the outgrowth of a course in the use of chemical literature which has given the author opportunity to ascertain what the students want to know. Therefore, he has been able to anticipate and answer the questions of chemists as a whole. There is no doubt that the book is full of thoughtful advice and in the hands of the young research worker is an invaluable source of information. It is recommended without reservation to chemistry students, chemistry librarians, teachers of the use of chemical literature, and to all others who feel at a loss as to how and where best to begin to utilize the chemical library.

VIRGINIA BARTOW

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INTRODUCTORY GENERAL CHEMISTRY. *Stuart R. Brinkley,* Associate Professor of Chemistry, Yale University. Revised Edition. The Macmillan Co., New York City, 1938. x + 731 pp. 176 figs. 14 × 21.5 cm. $3.50.

This book is strikingly different from most of the current introductory chemistry texts. Professor Brinkley presents several novel ideas in point of view and order of presentation of subject matter and weaves them into a well-organized plan. Every teacher who sees the book will want a copy for reference; he who plans to teach a rigorous and scholarly course will wish to examine it with a view to adoption.

The first third of the book follows the usual plan, but is somewhat more detailed than most introductory books. For example, under the determination of molecular weights we find descriptions of the Dumas and Victor Meyer methods and a discussion of Raoult's Law, with illustrative problems and diagrams. The chapter on the halogens (which are discussed as a group) occupies eighteen pages and that on the hydrohalides, thirteen pages. These chapters, and the following one on the alkali metals, furnish a background for the discussion of the periodic system which follows. This, in turn, is followed by chapters on Atomic Structure, Ionization, and Electrolysis. This sequence, while unusual, introduces the subjects in a logical and natural manner. Once introduced, they are used freely, and the latter half of the book utilizes electronic formulas and ionic equations in large number. The author intends that the book shall serve as an introduction to qualitative analysis, and discusses the necessary theoretical concepts in some detail. The analytical behavior of the various metallic ions is touched upon only briefly, although the description of the metals and their salts is given more space than in most of the recent elementary texts—about one hundred fifty pages.

The book is up to date in both theory and practice. The Debye-Hückel and Brønsted concepts are used freely, and recent experimental work, such as that on deuterium and atomic transmutation, is discussed. Several new industrial developments are described. Production figures for important chemicals are given for 1936.

Several other features of INTRODUCTORY GENERAL CHEMISTRY deserve mention. These include the numerous full-page portraits of eminent chemists, the brief historical sketches with which the book abounds, and the many applications of chemistry to industry. Each chapter concludes with a group of study exercises and references for additional reading. A section on organic chemistry, occupying fifty pages, is placed at the end of the book.

In this book, Professor Brinkley has produced a scholarly, yet teachable, text which should receive wide attention. The printing and binding are splendid, and considering the size of the book, the price is surprisingly low.

JOHN C. BAILAR, JR.

UNIVERSITY OF ILLINOIS
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THE FINE STRUCTURE OF MATTER: PART II, MOLECULAR POLARIZATION. *C. H. Douglas Clark.* Assistant Lecturer in Inorganic Chemistry in the University of Leeds. John Wiley and Sons, Inc., New York City, 1938. lxv + 240 pp. 124 figs. 13.5 × 22 cm. $4.50.

This book is Part II of Volume II of a projected three-volume comprehensive treatise by the author on atomic and molecular structure. This part, which forms a complete book in itself includes references to almost all of the experimental and theoretical papers published on the subject of molecular polarization up to 1935.

The part starts with Chapter X on dielectric constants. This chapter contains a brief résumé, without discussion, of a few theoretical laws, and then proceeds to summarize the results of some two hundred seventy experimental papers, to which references are given.

The Debye Theory of Polarization is treated, with references to thirty-five theoretical papers in Chapter XI.

Chapter XII, on Molecular Refraction, deals mostly with experimental results, again quoting from approximately a hundred papers.

Chapter XIII, on Polar Molecules, summarizes the methods determining permanent dipole moments, and lists many of the results. The Kerr effect is treated at the end of the chapter. The

literature references in this chapter number almost four hundred.

The part closes with a short chapter, XIV, on molecular fields. The discussion here concerns modern theories.

Partly because of a commendable attempt at completeness the book lacks some of the fluency and continuity of thought which is desirable in the textbook for class use or self study. It should be extremely valuable, however, to the specialized worker in the field, seeking to find a compendium of information available up to the time of publication.

In view of the inherent difficulties of the author's task it is perhaps unjust to criticize him for failure to meet successfully all of the desires of all types of readers. Nevertheless, the book seems, in certain respects, to fulfil some of these desiderata less well than could have been hoped, even without sacrifice of the admirable brevity and completeness of the treatment.

The author is evidently consciously and conscientiously uncritical in his reviews of papers. This is carried to the extent of omitting any comprehensive discussion of the assumptions involved in the derivation of the theoretical equations discussed. Since the author actually goes through the mathematical derivation of some of these equations the omission is not entirely to be laid to a desire for brevity. Thus the reader is often left entirely at sea whether experimental deviations from the theoretical equation, which are often quoted in considerable detail, are due to an inherent error in the reasoning involved in its derivation, as is occasionally the case, or due to some deviation in the substance investigated from the ideal behavior assumed in the derivation.

An example which must be disturbing to the student may be mentioned. The author cites Maxwell's conclusion that the dielectric constant $\epsilon$ is the same as the square of the index of refraction $r$ extrapolated to infinite wave-length. Apparent deviations from this law are discussed frequently, and considerable use is made of these deviations. It is, however, apparently nowhere explicitly mentioned that Maxwell's theoretical conclusion is absolutely accurate, and that the deviation is solely due to the fact that both experimentally and theoretically the smooth extrapolation of $r$ from the visible region to infinite wave-length differs from the correct extrapolation from measurements made in the far infra-red.

Largely because of this reticence of the author to discuss the assumptions underlying attempts at theoretical developments, Chapter XI, on the Debye theory of Polarization, and Chapter XIV, on molecular fields, are somewhat inadequate.

The book is scarcely to be recommended as a text, but is without doubt an important compendium of the available scientific information in the field. It is, therefore, a valuable reference book.

JOSEPH E. MAYER

JOHNS HOPKINS UNIVERSITY
BALTIMORE, MARYLAND

THE FINE STRUCTURE OF MATTER. PART III, THE QUANTUM THEORY AND LINE SPECTRA. *C. H. Douglas Clark*, University of Leeds. John Wiley and Sons, Inc., New York City, 1938. lxxii + 185 pp. 28 figs. 13.5 × 22 cm. $4.50.

As intimated by the title, this volume forms the third part of a series, of which Part I deals with X-rays and the structure of matter, and Part II with molecular polarization. The volume under review contains Chapters XV to XVIII of the series inclusive. In the first of these chapters a brief review is given of the different quantum effects, and mention is made of the observations on the diffraction of electrons. This is the only place in the volume in which electron waves are discussed. The subject of wave mechanics is completely omitted. The second chapter contains a review of the Bohr orbital theory of the origin of line spectra, and the third deals with the application to atomic spectra of the hypothesis of the spinning electron. The subheadings in this chapter are as follows: The Spinning Electron, Selection and Intensity Rules, The Fine Structure of Lines in Hydrogen and Ionized Helium, Multiplicity Rules and Term Intervals, and The Ground Terms of Atoms and Ions. In the last chapter there are discussed the magnetic energy levels of hydrogen, the Pauli Exclusion Principle, and the application to the periodic classification of the elements and the observations on valency.

A very comprehensive bibliography is attached to each of the chapters.

For those who wish to obtain a presentation of the theory of line spectra in its simplest aspects, that is from the point of view of Bohr and Sommerfeld, this volume should prove very helpful. It is, however, a question whether it is justifiable in a discussion of the subject of spectra to omit completely any reference to the quantum mechanics interpretation of energy levels and spectral lines, especially since these concepts, as developed during the past decade, are of such essential importance for a satisfactory interpretation of chemical valence and of the nature of the solid state.

SAUL DUSHMAN

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SEMI-MICRO QUALITATIVE ANALYSIS. *Paul Arthur*, Ph.D., Assistant Professor of Analytical Chemistry, and *Otto M. Smith*, Ph.D., Professor of Chemistry, both at the Oklahoma Agricultural and Mechanical College. First Edition. McGraw-Hill Book Company, Inc., New York City, 1938. xi + 198 pp. 10 figs. 13.5 × 20.5 cm. $2.00.

This new volume of the International Chemical Series attempts to give in condensed form a description of semimicro methods (Part I, twelve pages: Semimicro technic and construction of apparatus), the theory of analysis (Part II, fifty-six pages: Important principles, Mathematical relationships, Modern theories of electrolytes, Organic compounds in analysis), the analytical procedure for the detection of cations (Part III, seventy-one pages) and the procedure for the detection of anions (Part IV, fifteen pages). A series of problems, some special notes on analytical procedure, references to the original literature, an appendix with numerical tables, lists of apparatus and reagents, and an index, complete the book.

In Part I, the authors briefly describe the essential methods of semimicro analysis, and give ingenious instructions for the conversion of ordinary equipment into microapparatus. These methods are probably quite suitable for use in small classes, but the reviewer is somewhat skeptical as to the advisability of adopting them in the case of large groups of students, particularly if qualitative analysis is given as a portion of the freshman chemistry course, *i. e.*, at a moment when so much in the standard methods is still to be learned. This is, however, a debatable point and more evidence of the kind gathered by the authors in their classes is needed.

Part II begins with a qualitative discussion of some of the important principles of the theory of electrolytes. Derivations of most formulas are purposely left out. As a result, several paragraphs are vague and inadequate, in particular the one on amphoteric hydroxides. There follows a section in which two common types of problems are discussed: problems on the ionization of weak electrolytes and problems on solubility products, but there are no problems in which the two types are combined. The all-important relationships describing the ionization of hydrogen sulfide are not used and are not even mentioned in the discussion of principles. The following section, entitled Modern Theories of Electrolytes, is entirely out of place in such an elementary and sketchy treatment. The Debye-Hückel theory does not lend itself to oversimplification of the kind offered here. Several statements are definitely incorrect, or so vague as to be meaningless (in particular paragraphs two and three, page sixty-four on the "sphere of influence"). The limiting law for the activity coefficient derived by Debye and Hückel is defined (footnote, page 64) as a simplified formula developed by Brønsted and La Mer!

The experimental portions of the book are definitely more satisfactory. The authors would have made a more valuable contri-

bution to chemical education if they had limited their book to the description of the semimicro technic and of the various reactions for cations and anions, and had referred the reader to other tests for the theory. The charts for group analysis are clear and give in compact form all the necessary details. On pp. 124–136 an interesting and very helpful list of auxiliary tests for most of the usual cations is given. Recent progress in analytical chemistry seems to have been incorporated in the text wherever possible. A curious detail struck the reviewer: cations are always mentioned in the singular ("mercurous ion, $Hg_2^{++}$" as a subtitle, and so forth), but anions, for some strange reason, are deemed worthy of the plural ("cyanide ions, $CN^-$" as a subtitle, "$Cl^-$ are present," and so forth). This brings us to the subject of form, style, and presentation, but our review should then be extended to most of the contemporary scientific literature.

PIERRE VAN RYSSELBERGHE

STANFORD UNIVERSITY
STANFORD UNIVERSITY, CALIFORNIA

CHEMICAL KINETICS. *Farrington Daniels*, Professor of Chemistry in the University of Wisconsin. Cornell University Press, Ithaca, New York, 1938. viii + 273 pp. 41 figs. 15 × 23 cm. $3.25.

This book is based on the George Fisher Baker lectures delivered by Professor Daniels at Cornell University in the spring of 1935, with material added to bring the manuscript up to date, as of the beginning of 1937. It is addressed primarily to the student who has a good foundation in physical chemistry, but who is without special knowledge in kinetics. For such a student the book should prove a good introduction to the subject, and it should give him a reasonably accurate idea of its present state of development. Parts of the book will also be of considerable interest to workers in the field.

The books starts out with a review of general principles, including the definition of the order of a reaction and a discussion of the Arrhenius principle. It then goes on with a qualitative discussion of unimolecular reactions, including both simple reactions and chain reactions, these principles being illustrated in the next chapter by some specific examples. Next, there is a brief account of the kinetics of reaction in solution, followed by a fairly detailed chapter on photochemistry. There is a brief chapter on electrical activation. In a chapter on infra-red spectroscopy the author presents a subject which is related to chemical kinetics and which may play a more important rôle in its future development. Then comes a perhaps too brief presentation of the theoretical calculation of activation energies, including a rather incomplete account of the statistical mechanical calculation of absolute reaction velocities. The book closes with an interesting account of the use of isotopes to trace reaction mechanisms.

In general, the author's method is to present first the theoretical aspects of any given subject and to illustrate the ideas thus developed by means of specific examples. In the theoretical parts of the book general ideas are stressed rather than quantitative calculations. These portions should be helpful to students who wish to gain a general knowledge of the subject, or wish an introduction before entering into more detailed calculations. The reviewer should, however, note that he is not in complete accord with all of the theoretical treatment, and believes that in the attempt to oversimplify, some erroneous statements have crept in. While these may be misleading at times, they do not detract greatly from the value of the book as a whole.

The examples which are used for illustrative material are drawn chiefly from the work of the author and his students and former students. This is true to some extent of the material selected for theoretical discussion also. However, this is part of the purpose of the Baker lectures; as stated in the introduction, the lecturer "is not only permitted but expected to talk chiefly about his own work." While this necessarily causes a certain lack of balance in the presentation, so much of value has come out of the Wisconsin laboratory that the author's colleagues will welcome the presentation of this material. Experimental methods and descriptions of the apparatus used are often given in considerable detail, and these sections will be of direct value to the research worker, while at the same time giving the beginner an idea of the technic used in investigations in kinetics.

The reviewer notes with interest that a number of biological systems are discussed in more or less detail. These discussions will serve to indicate the growing importance of kinetic studies to biochemistry.

From this account it will be seen that the volume under review has features that will interest a variety of readers. There are relatively few books in the rapidly growing field of chemical kinetics, and this one fills a place which is occupied by none of the others.

O. K. RICE

UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, NORTH CAROLINA

LABORATORY METHODS OF PHYSICAL CHEMISTRY. *Joseph J. Jasper*, Assistant Professor of Chemistry, Wayne University. Houghton Mifflin Company, Boston, Massachusetts, 1938. xix + 312 pp. 35 figs. 14.5 × 22 cm. $2.50.

This book presents a series of experiments for use in a physical chemistry laboratory course and accompanies each experiment with a discussion of the theoretical principles involved. The topics covered are gases, liquids, optico-chemical methods, solutions, colloidal systems, thermochemistry, homogeneous equilibrium, chemical kinetics, phase equilibrium in chemical systems, conductance, transference numbers, electromotive force, and photochemistry. An excellent discussion of the theory pertaining to each topic is given before the directions for performing the experiment. The student is encouraged to examine the results in the light of known errors and to keep experimental errors as low as possible. After the description of how to perform each experiment a paragraph is headed "Treatment of Results." The author has succeeded very well in encouraging a study and interpretation of the results. The aim throughout is to stimulate the student to think about further applications and develop a research feeling. The book is more than a mere laboratory manual and deserves consideration by teachers and students interested in physical chemistry. It should be a very successful book in any physical chemistry course.

ARTHUR A. VERNON

NORTHEASTERN UNIVERSITY
BOSTON, MASSACHUSETTS

BRITISH CHEMICAL INDUSTRY: ITS RISE AND DEVELOPMENT. *Sir Gilbert T. Morgan* and *David Doig Pratt*. Longmans, Green and Company, New York City, 1938. xii + 387 pp. 78 figs. 18.5 × 24.5 cm. $6.25.

This book incorporates the substance of a series of Public Lectures delivered at the University College of Wales. The purpose of the authors is to provide a comprehensive survey of the development of the British chemical industry from its early beginnings to its present state.

The summary is arranged so that each chemical manufacture is grouped, as far as possible, with the naturally occurring raw material upon which it depends. For example, the first chapter which is entitled Salt, includes the alkali industries as well as hydrochloric acid, chlorine, and its derivatives. Subsequent chapters deal with the following raw materials: sulfur; sand, clay, and limestone; air and industrial gases; metalliferous ores; borax and phosphates; oils, fats, and waxes; cellulose; coal; oil shale and petroleum; rubber. Additional chapters are devoted to the following subjects: paints and pigments; explosives; dyestuffs and intermediates; plastics; industrial solvents; fine chemicals.

In addition to the historical review of each industry the book contains detailed descriptions of the latest manufacturing processes, in many cases presenting equations showing the chemical reactions involved, photographs and drawings of special equipment, and charts illustrating the steps leading from the raw materials to the various manufactured products. The chapter on dyestuffs and intermediates is particularly complete; with struc-

tural formulas showing the chemical composition of the early synthetic dyes such as mauve and magenta, synthetic alizarin and allied dyes, indigo and typical indigoid vat dyes, anthraquinone vat dyes including the solubilized types, sulfur dyes, and specialized dyes for acetate rayon.

The chapter on fine chemicals includes flavoring essences, perfumes and cosmetics, photographic chemicals, disinfectants and antiseptics, fungicides and insecticides, pharmaceutical products with particular emphasis on anesthetics, soporifics, antipyretics, hormones, and vitamins.

This book is extremely interesting from the standpoint of chemical education, because the development of the chemical industry in England is closely interrelated with similar developments in the rest of the world. Thus a great many of the latest achievements in every branch of chemical manufacturing are here recorded in a very clear and concise manner.

The volume is bound in Sundour Fadeless Bookcloth which was dyed with Monastrol Fast Green GS, a recently synthesized organic pigment which is very fast to light.

WALTER M. SCOTT

GUSTAVUS J. ESSELEN, INC.
BOSTON, MASSACHUSETTS

AN INTRODUCTION TO CHEMISTRY. *John C. Hogg*, M.C., M.A., The Phillips Exeter Academy. Oxford University Press, Inc., New York City, 1938. ix + 365 pp. 115 figs. 13.5 × 22 cm. $2.00.

This book will challenge the attention of those teachers interested in revising the curriculum to more nearly meet the needs of the present high-school population, and those interested in avoiding so much duplication in high-school and college chemistry content. In his preface, the author states he is reaching his goal by stressing the historical approach which he claims gives a cultural setting, is free from difficulties inherent in the study of industrial processes, is logical, develops the spirit of an explorer, and is full of interest. The book is intended primarily for those who are free from the threat of examinations. Ionization and the theoretical study of gas volumes has been deliberately omitted. Five elements, oxygen, hydrogen, nitrogen, sulfur, and carbon, are studied in detail. The course is planned for tenth- and eleventh-grade students.

There may be much questioning as to the choice of material for the present-day youth who, stimulated by movie, radio, magazine articles, inventions, and so forth, is interested in the chemistry of his everyday life—the chemistry of such things as photography, the airplane, the automobile, his food, his clothing, and his own body.

The physical make-up of the volume is attractive. The paper is good, the print clear, and the numerous pictures and diagrams well chosen and definite. The book is written in a style and with a vocabulary that demands a well-trained background. It will probably prove difficult and, therefore, uninteresting to the mediocre student. It opens with a brief discussion of the development of chemistry from 3000 B.C. through the time of Lavoisier. Then follows a discussion of physical and chemical changes; elements, compounds, and mixtures; oxygen; atoms and symbols; hydrogen; formulas and equations; water; chemical calculations; carbon and its oxides; fuels; the atmosphere; acids, bases, and salts; sulfur and some of its compounds; the laws of definite and multiple proportion; and a short chapter on crystals. Throughout the discussion biographical material is continued in an interesting and logical fashion wherever it is pertinent. Constant reference to the root of the chemical words is made. Appendix II is an index of the principal chemical terms having a foreign origin.

Interspersed in the discussion are one hundred five experiments, many of them quantitative. Several of these experiments demand much time and are, therefore, impractical in a school which gives but an hour a day for a science class. The author fails to state whether the experiments are to be performed by a teacher or a pupil. If by the latter the directions are often too inadequate to prevent possible accidents to the inexperienced. As an example, in Experiment 5, no precautions are given for handling yellow phosphorus. In many of the non-quantitative experiments the results to be obtained are described in detail. All that the student can gain from them is a verification of already stated facts, and facility in handling apparatus. His chance for developing the spirit of an explorer is thereby limited.

As a whole this excellent book is highly academic and will certainly give to the student using it a splendid background in the material covered.

HATTIE D. F. HAUB

ROOSEVELT HIGH SCHOOL
OAKLAND, CALIFORNIA

QUALITATIVE ANALYSIS OF INORGANIC MATERIALS. *W. B. Meldrum* and *E. W. Flosdorf*. American Book Company, New York City, 1938. xiii + 230 pp. 14 × 22 cm. $2.50.

This book is divided into two main parts: Fundamental Principles, eighty-six pages, and Laboratory Work, one hundred fourteen pages with an appendix of eighteen pages. It aims to present material that may be used for the laboratory work in the latter part of general chemistry and for both class and laboratory work for a following course in qualitative analysis. In covering this ground in a fairly small book it has been necessary to condense the presentation of certain topics, to limit the explanation of procedures to a certain extent, and to make considerable use of cross references to avoid repetition.

In the laboratory the student is expected first to become familiar with the common reactions of the cations and anions, including a fair range of the organic reactions that have established themselves as useful confirmatory tests. Next is taken up the more readily soluble compounds of the cations and anions studied. Finally, a typical scheme for the systematic analysis of mixtures, both solutions and solids, is given in some detail. In this part of the book the main departure from common practice lies in attempting to treat the anions by a group procedure: Group I, volatile with $HC_2H_3O_2$; Group II, precipitating with $Ba(C_2H_3O_2)_2$ in neutral solution; Group III, precipitating with $AgC_2H_3O_2$; Group IV, not precipitated or removed by previous reagents.

The book is of convenient size, attractive in appearance, well bound, and well printed. There are relatively few typographical errors. There are more mistakes in direct statement of facts and in implications. On page 26 a problem is solved using $3.6 \times 10^{-18}$ for $K_{HPO_4^{--}}$, though the value is correctly given in the table on page 27. On page 33 the evolution of HCl by adding concentrated $H_2SO_4$ to a saturated solution of HCl is explained in terms of common ion effect, though the important factor in this case is the removal of solvent by the dehydrating action of the $H_2SO_4$. At the bottom of page 41, the concentration of $Ag^+$ in 0.1 *M* KCl solution saturated with AgCl does not represent the total solubility of the silver chloride, since many times that amount of silver will be present as $AgCl_3^{--}$. On page 74, when writing ionic equations to represent overall reactions, it seems much more logical when the compound is slightly ionized to write the formula for the compound rather than that of one of the ions as reagent. Thus the reducing agent for $FeCl_3$ is $H_2S$ rather than $S^{--}$, and mercuric chloride is $HgCl_2$ instead of $Hg^{++}$ and $2Cl^-$.

From the point of view of omissions, a brief treatment of Werner's Coördination Theory in modern terms would probably be more useful in relation to analytical chemistry than Brønsted's theory of acids and bases.

The book provides material to keep the student well occupied in the laboratory during the period of its intended use. In its condensed form, however, it would need to be expanded in class lectures and discussions, and it might prove unsatisfactory for use by one not trained in the points of view taken in several of the sections.

R. K. MCALPINE

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ANN ARBOR, MICHIGAN

# ANNUAL INDEX—JOURNAL OF CHEMICAL EDUCATION

## Volume 15, 1938

The annual index for Volume 15 of the JOURNAL OF CHEMICAL EDUCATION is divided into two parts—an Author Index and a Subject Index, each alphabetically arranged. Letters (Ar), (Ab), (B), (C), (E), (F), and (P) have been used after the various items to designate, respectively: article, abstract, book review, correspondence, editorial, frontispiece, and portrait or picture.

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Face piece is of soft rubber that makes an air-tight fit. A face cloth is provided both for comfort and as a safeguard against dermatitis. The trade name is DUPOR No. 10, made by H. S. Cover, South Bend, Indiana.

### New Inexpensive Micro Oven

A new inexpensive Micro Oven has just been announced by the *Fisher Scientific Company, 711 Forbes Street, Pittsburgh, Pa.* This oven is designed to accommodate micro crucibles, beakers, and other containers that are likely to be "lost," tipped over, or contaminated in the laboratory's large oven. This Micro Oven provides temperatures from 40 degrees Centigrade to 125 degrees Centigrade in the air chamber. The heating unit is a thermostatically controlled hot plate which will reproduce and maintain even temperatures. The temperature of the hot plate is regulated by adjusting the thermostat within the plate.

The hot plate has a chromium-plated top which is four inches in diameter. The air chamber, which rests on the hot surface, is made of Pyrex brand glass. It is easily removable by means of a fiber handle at the top. Temperature readings within the Oven can be made by inserting a thermometer through the fiber handle. A glass platform is supplied with the Oven so that materials can be held above and out of direct contact with the heating surface.

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### Acme Gas Masks Nos. 4 and 4A Approved by U. S. Bureau of Mines

The *Acme Protection Equipment Company, Inc., 3620 Liberty Ave., Pittsburgh, Pennsylvania,* manufacturers of respiratory protective devices, announces Official Approvals of Acme Full Vision Gas Masks Numbers 4 and 4A for organic vapors by the United States Bureau of Mines.

An outstanding and exclusive feature of these new masks is the Full Vision safety glass lenses which permit the wearer to see the same as when not wearing a mask. Another exclusive and important feature is the dead air check valves on the outlet ends of the fresh air ducts. These valves automatically open and close upon inhalation and exhalation, and prevent the accumulation of exhaled breath in the fresh air ducts.

A light weight, all-rubber face piece, fully molded and cured to master face fitting proportions, provides the wearer with the utmost comfort. There are no rivets, threads, or adhesive tape pads to irritate the face, and the head harness buckles are incorporated in such a way as to eliminate uncomfortable pressure points on the wearer's face and forehead.

The new Acme Full Vision Gas Mask weighs less than any other approved Gas Mask.

Copies of informative new literature just off the press, designated as Folder M387, may be secured from the manufacturer.

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### Rectifier for Arcs

School and college laboratories use instruments that have as a light source arc lamps that use 6 millimeter carbons. These lamps will operate AC or DC, but DC operation is preferred because it results in the brightest possible image on the screen. It is a characteristic of a DC arc that it is most intense at one small spot on the negative carbon and this makes it easy for the operator to align the light source on the optical axis of the projector and maintain a steady, continuous arc. There also is the advantage that the arc strikes quickly and is maintained easily, free from sputtering and troublesome interruption.

To provide DC of the proper characteristics for all makes of 6 millimeter carbon arc lamps the portable Raytheon Rectifier, catalog number 1072, has been designed to convert 115 volts AC to 60 volts, 5 amperes DC.

Compactness and high efficiency both result from the use of a new Raytheon RX-207 tube to obtain rectification and a built-in efficient current limiting transformer, which gives the same operating results formerly obtained only with wasteful external ballast resistors. There are no adjustments. You simply plug the Rectifier into the 115-volt AC supply and plug the arc lamp into the DC output receptacle.

An illustrated bulletin has been prepared giving prices and a full description, which may be obtained by writing Raytheon Manufacturing Company, Willow St., Waltham, Massachusetts, and requesting Bulletin D148-237.